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INDUSTRIAL ENGINEER

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Good Service Is Worth the Price—

On the Other Hand, Indifferent or Poor Service from Men or Machines Breeds Trouble, Spoils Dispositions, Disrupts Things in General and is Expensive at Any Price

DURING the past year or so I have been able with the help of some old-timers who remember the kind of service first invaded by a motor and had a hand in this work, to give on this page some interesting examples of what seem to me to be two very important truths.

First, a good piece of apparatus like a motor that can tell a story of service without expensive repairs for eighteen or twenty years, is cheap at the top price that is asked for it. One which falls short of half this measure of service is expensive at any price.

Second, that motors have been built better than the designers really knew and details of correct installation are now more important than new refinements in design which, if needed at all, must usually be justified by competition in meeting a lower price.

Motors are bought to use and not to repair, so that service after all is the proof of good design, good workmanship and a fair price. Records of a few cases that measure up to these standards have been given on this page in past issues of INDUSTRIAL ENGINEER.

The accompanying photograph tells another interesting story of service from two Westinghouse generators, each rated 150 kw., operated at 220 volts, and direct-connected to Ball high-speed engines. These generators were installed in the Chamberlain Hotel in Des Moines, Iowa, in 1904 and have since furnished light for the building and power for operating elevators and other equipment. These machines are still in fine condition and good for some years to come. In checking up the service on these machines, Dr. E. S. Chamberlain, President of the Chamberlain Medicine Company at Des Moines, has written me as follows:

This is in reply to your favor of September 26. In January, 1904 I purchased two 150-kw. Westinghouse generators direct from the Westinghouse Company at Pittsburgh, Pa., and also two Ball engines direct from the Ball Engine Company at Erie, Pa. These were installed in the Chamberlain Hotel and I believe they have been in constant use ever since. I know they did excellent work while I was connected with the hotel and for ten years after, while W. L. Brown was in charge.

C. H. Hartnagle, present manager of the Chamberlain Hotel at Des Moines, has written me as follows about this equipment:

During the past ten years the only repairs that have been made to our engine-driven, Westinghouse generators have been turning of the commutator of one of them and replacing the eccentric on one engine. During this period there have been four different chief engineers in charge of our plant, and previous to that time there were two others who operated the plant from the time it was installed. The equipment at this time is in very good condition. The windings and insulation are apparently as good as new. We believe that the reason for the good service we have had is because the equipment was very good and that it has been operated and kept up by good engineers.

To be sure, some of the early designs shown are now relics, but their service furnishes practical information on which theorists can theorize some more on motor depreciation and what may be expected as a satisfactory useful life.

Practical Pete

A Glimpse into the Works of the

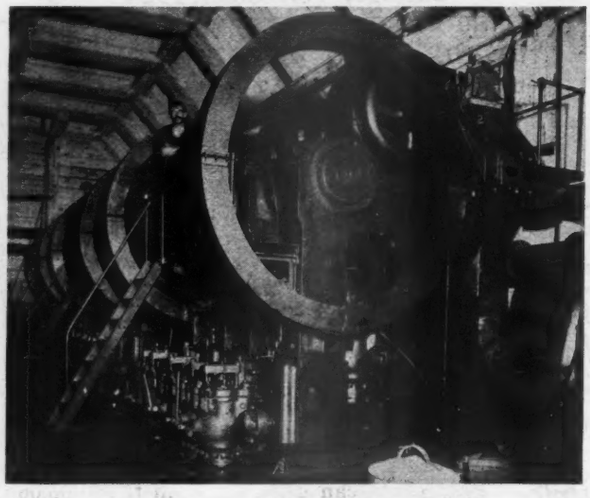
Anaconda Copper Mining Company

Which mines, smelts and refines copper ore, producing forty million pounds of electrolytic copper monthly, and through its manufacturing organization, The American Brass Company, produces copper and copper-alloy materials and shapes

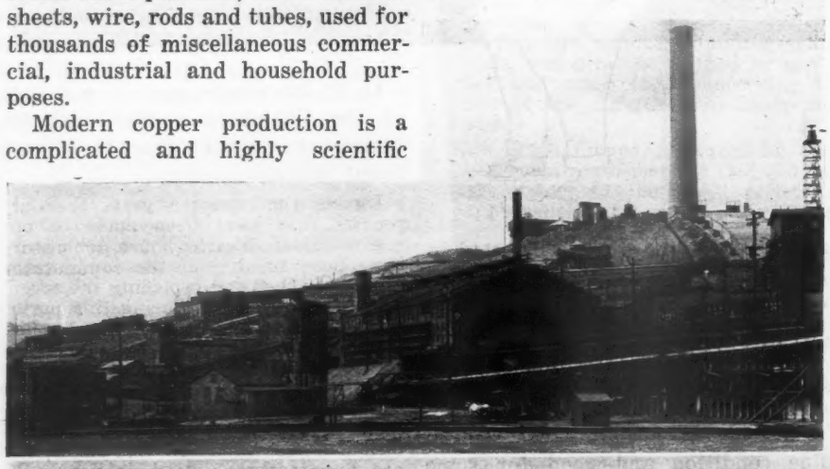
THE United States is producing 60 per cent of the world's output of copper and consumed in 1923 over 1,500,000,000 lb. or more than 75 per cent of all copper mined.

The Anaconda Copper Mining Company has, through its association with The American Brass Company, established for the first time a unified service from copper mine to the ultimate consumer of copper products. One organization is responsible for every operation—from the time the ore is extracted from the earth and converted into virgin metal until it is wrought into a wide variety of copper, brass, bronze and nickel silver products, in the form of sheets, wire, rods and tubes, used for thousands of miscellaneous commercial, industrial and household purposes.

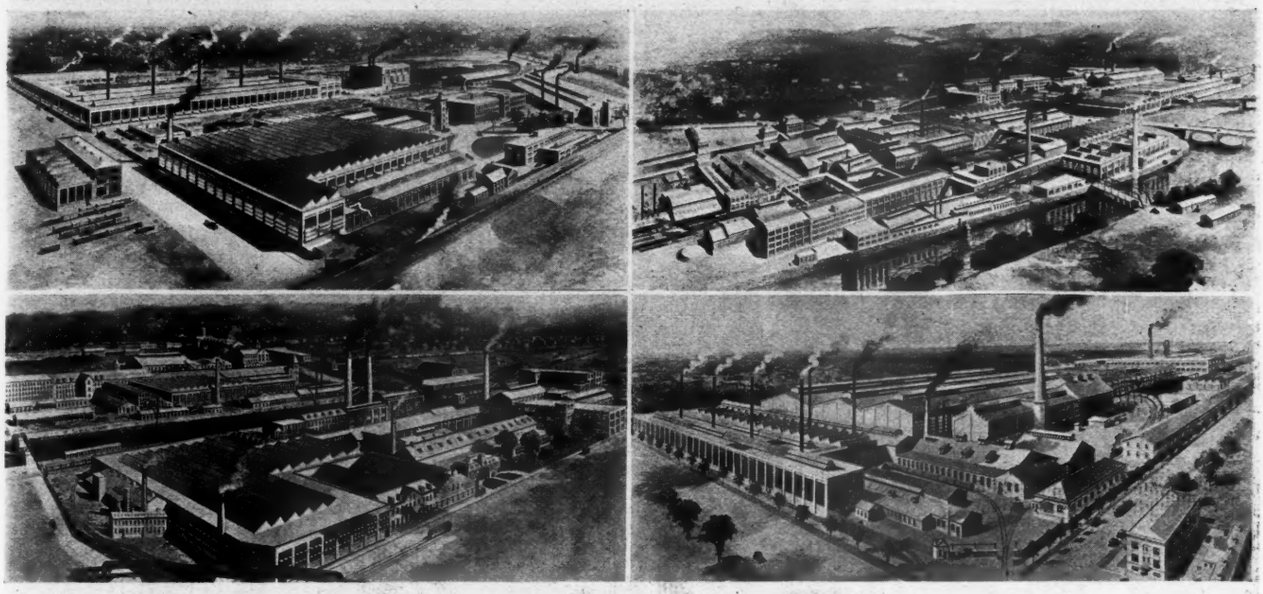
Modern copper production is a complicated and highly scientific process. The mining operation yields ore which then undergoes a variety of treatments, such as concentration, roasting, smelting and converting, and finally emerges in metallic form. Some idea of the size of Anaconda operations in Montana is obtained from the fact that during the past forty years the Anaconda Copper Mining Company has produced there a total of 100,000,000 tons of copper ore, which would fill a train 13,000 miles long. The copper content of this amounted to over 4,000,000 tons or 4 per cent of the ore mined. If it were all drawn into copper wire, such as is used in telegraph or telephone lines, this copper would reach 50,000,000 miles.



One of the big problems is pumping water from the mines. This shows a battery of quintuplex vertical electric pumps with a capacity of 600 gal. per min., under a head of 1,200 ft. Each pump is direct connected to two 150-hp., 2,300-volt motors. These pumps are operated underground at High Ore Mine, Butte, Mont.



About 90 per cent of all copper consumed in the United States last year was refined by the electrolytic process, which produces pure, high-conductivity copper. All Anaconda copper is electrolytically refined, either at Great Falls, Mont., or at Perth Amboy, N. J., adjacent to New York harbor. The plant at Perth Amboy is one of the largest electrolytic copper refineries in the world, covering an area of forty acres and having refining capacity of about



Four of the manufacturing plants of The American Brass Co.

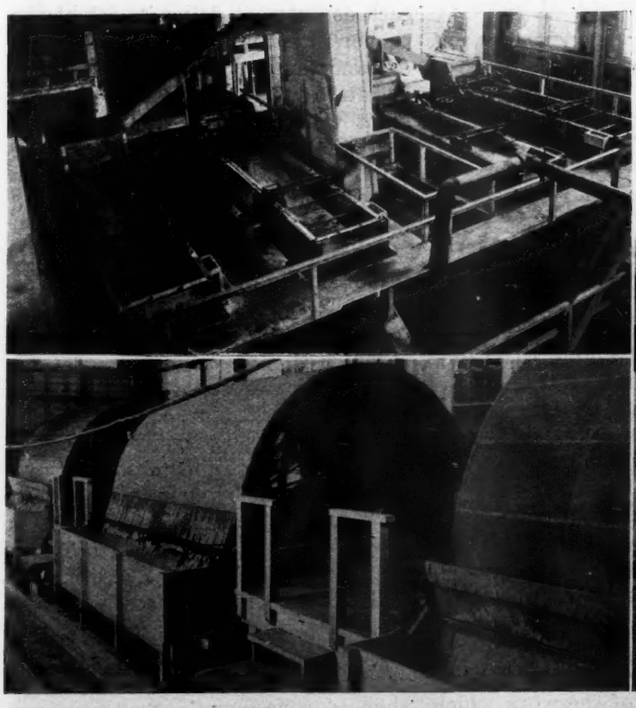
The two plants at the left are located at Waterbury, Conn., the main office of The American Brass Company. The two at the right are at Ansonia, Conn. (top) and Kenosha, Wis. This company is the world's largest manufacturer of copper and copper alloys in the form of sheets, wire, rods, tubes and special shapes. The seven plants located near the industrial centers turn out in excess of 600,000,000 lb. annually.

40,000,000 lb. of copper monthly.

The American Brass Company, with headquarters at Waterbury, Conn., is the world's largest manufacturer of copper and all combinations of copper, zinc, lead, tin and nickel, which can be wrought in the form of sheets, wire, rods, tubes and special shapes. The Anaconda Copper Mining Company also operates a rod and wire mill with a capacity of 125,000,000 lb. per year, at Great Falls, Mont.

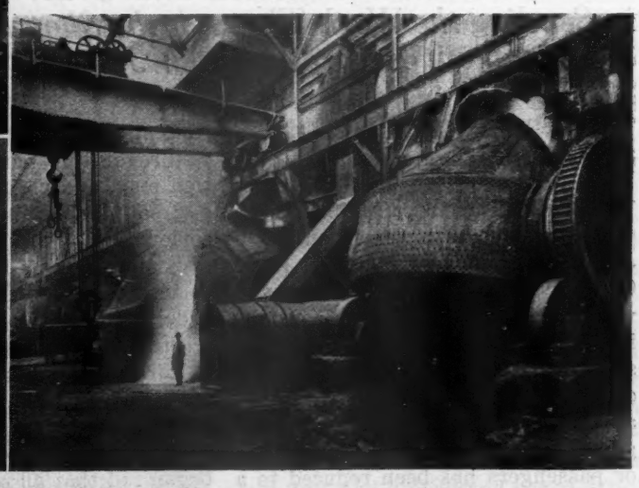
The growth of the electrical industry is, in part, responsible for the greatly increased use of copper. This industry now accounts for about 60 per cent of the total domestic copper consumption, or about 900,000,000 lb. a year. Hydro-electric development now under way promises to add greatly to the electrical industry's consumption of copper, for each kilowatt of energy developed requires approximately 8 lb. of copper.

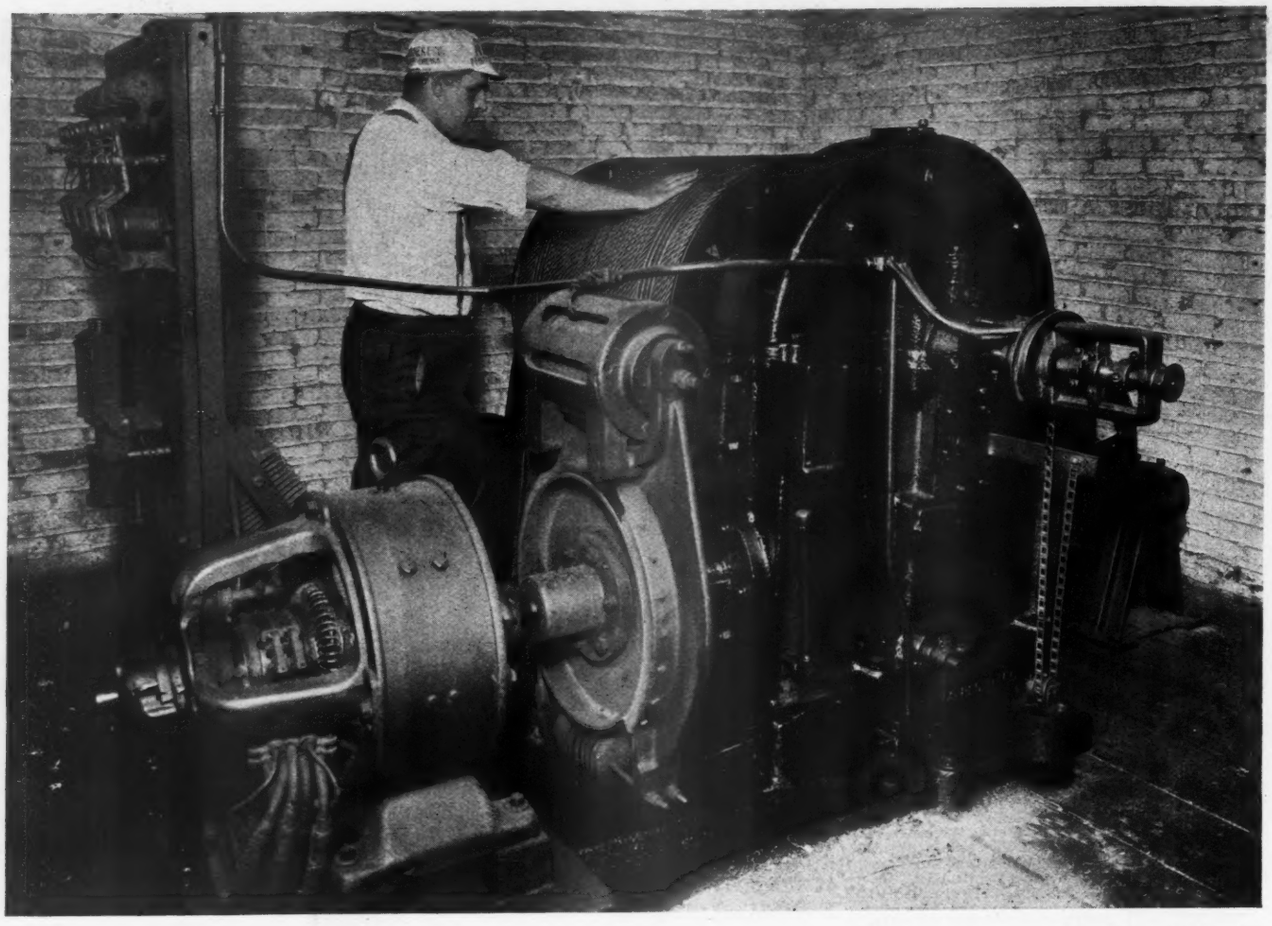
Copper, brass and bronze come into numberless uses in building, as hardware fixtures, as wire, and as screening; (*Continued on page 556*)



Three important steps in the smelting of copper.

Much of the ore has to have the sulphur roasted out of it first. The ore is then ground and washed in Hancock jigs (upper left) which concentrate the ore. The illustrations in the lower left corner show the Oliver filters for removing the water from the concentrate, before smelting. In the converting process (below) 65-ton charges of molten matter with a copper content of from 40 to 50 per cent have air under pressure of 16 lb. per sq. in. blown through the liquid mass to burn off the remaining sulphur and slag the iron. In addition to copper, gold and silver in small amounts are also recovered from the ores.





The inspector shown here is finishing up his work on the elevator machine by watching and feeling the cables for broken wires and other defects.

Details of Procedure in

Repairing and Rebuilding Electric Elevators

With the Routine Followed and Order Forms Used in Sending the Work Through the Shop and Keeping a Permanent Record of Each Job

By R. H. KUEHMSTED
Vice President, Thompson and Jameson, Inc., Chicago, Illinois

ELEVATOR repair work is in most cases an emergency job and must be handled as such. Contrary to the general opinion, elevator accidents such as the car falling, cables breaking and so on, are seldom fatal, so far as human life is concerned, because modern safety appliances are so efficient that danger of serious injury to the operator or passengers has been reduced to a minimum. However, elevators are used so widely for carrying both passengers and freight that any failure of this mode of transportation may, and usually does, result in a great deal of inconvenience or a serious delay in production. In any event it is a situation which must be cleared up as quickly as possible in order that service may be restored with the least possible delay.

For many years we have specialized in the installation and repair of electric elevators and inasmuch as this means that our plant must be so organized that all of the work which comes in can be scheduled and handled with the utmost despatch, with each department doing its job at the proper time, an account of our methods and the routine followed may be of interest. In addition to the elevator work mentioned above, we do a large amount of business in the repair of motors and starting equipment, and the sale and rental of used motors.

There are approximately fifty different makes of electric elevators in use. These are made in various designs and sizes, so that an attempt to carry in stock a complete set of replacement parts would result in tying up a large amount of capital and space. Further, many elevators now in use are either obsolete types or were made by firms which have gone out of business, so that it is very difficult or impossible to obtain spare parts. For these reasons we find that in many cases we must make new parts, as we can not buy them, although we do carry large stocks of certain parts. Our machine shop is, consequently, well equipped with all of the machine tools needed to turn out promptly any new parts

that may be needed. The machine shop is close to the shipping department and both are served by several chain hoists running on overhead I-beams, so that the heaviest parts or machines can easily be handled from one machine to another, or between departments. A portion of the machine shop is shown in Fig. 1.

The motor repair, controller and other departments are likewise thoroughly equipped with coil-winding and taping machines, dipping tanks, baking ovens, testing apparatus and other devices for repairing or rebuilding any equipment of this nature. Fig. 3 shows a section of the coil-winding department.

TRANSPORTATION of both passengers and freight by means of elevators is such an important factor in the operation of modern industrial plants that any interruption of this service is attended by serious delays and inconvenience. When such interruptions do occur it is usually imperative that the cause of the trouble be located and the necessary repairs made as soon as possible. In this article Mr. Kuehmsted describes the order systems used, shop routine followed and records kept by an organization which has for many years specialized in the installation, repair and maintenance of all types of electric elevators.

Routine Method of Handling Elevator Repairs

Considering for the moment the elevator repair division of our business, when a trouble call comes in, usually over the telephone, the person who takes the message fills out the form shown in Fig 2 *A*. This form is made out in duplicate, white and blue. When the data is complete, the blue copy is filed and the white copy is given to the salesman in that territory. Incidentally, this form is used for inquiries of every nature, including the sale or repair of motors or other equipment, and so on.

If the customer waives the formality of an estimate, as is frequently the case, an order form, Fig. 2 *H*, covering the work required, is made out.

In either event an inspector is then sent at once to the plant or building where the defective elevator is located. He makes a thorough examination to determine the nature and extent of the repairs needed. These may vary from the replacement of a small part or minor adjustment, to practically rebuilding the winding machine, rewinding the motor or completely overhauling the control. If an estimate is required, the results of this inspection are entered on the form in Fig. 2 *A*, for our records.

A written proposal is then immediately drawn up in the form shown in Fig. 2 *B*, and submitted to the customer. As will be noted this proposal completely covers the transaction, including the work to be done, material to be furnished and price and terms of payment. This proposal is, of course, made out in duplicate; one copy goes to the customer and one is placed in our files.

If an estimate has been requested, we wait until the customer accepts the proposal; otherwise work is immediately started on the job. If it is necessary to dismantle any part of the elevator mechanism and take it to the shop for repairs, this is done.

When a badly worn or broken machine or part is sent in from a job the first step is to attach to it the Repair Tag, shown in Fig. 5. This tag is made out in duplicate, a heavy yellow sheet which is wired or tied to the part, and a white Inspection Report, both of which bear the job number. The part is inspected by the foreman or an inspector and the nature of the repairs noted and the report O. K.'d by the foreman or superintendent. The white Inspection Report is held in the *Inspection Department* until the repairs are complete and the part ready for final inspection before shipment. The tag and sheet are then returned to the office and filed.

Drawings are then prepared, if needed, and the work sent to the machine shop. Here the necessary work is done and the new or repaired part is sent back to the job, after careful inspection and checking. The machine shop foreman records on the Machine Shop Record of Material and Operation Sheet, shown in Fig. 2 *G*, the material used, nature of operations and time required for the job. This sheet is then sent to the office where it is filed under the job number until all of the time and material tickets have been turned in.

Perhaps the motor driving the winding machine needs rewinding or overhauling. If so, it is sent to the motor repair department in our shop. Here it is examined carefully and the repairs necessary to put it in first-class condition are noted. If the armature has to be rewound, say, the foreman makes out the Armature Data and Coil Data cards shown in Figs. 2 *C* and 2 *F*, which give all of the winding data, with the job number. The Coil Data card is then sent to the coil winder for his guidance in making the coils. When these have been properly varnished and baked they are inserted in the armature or rotor in accordance with the data given on the Armature Data card. In many cases coils are laid first and dipped and baked after the armature or stator has been re-

Fig. 1—Part of the machine shop in which repairs to elevator equipment are made.

Because it is difficult or impossible to obtain replacement parts for many old-type or obsolete elevators, this machine shop is equipped to make any new part that may be needed, as well as perform any operations necessary in repairing or reconditioning worn parts. All machine work on motors, such as turning commutators, fitting new bearings, and the like, is also done here.

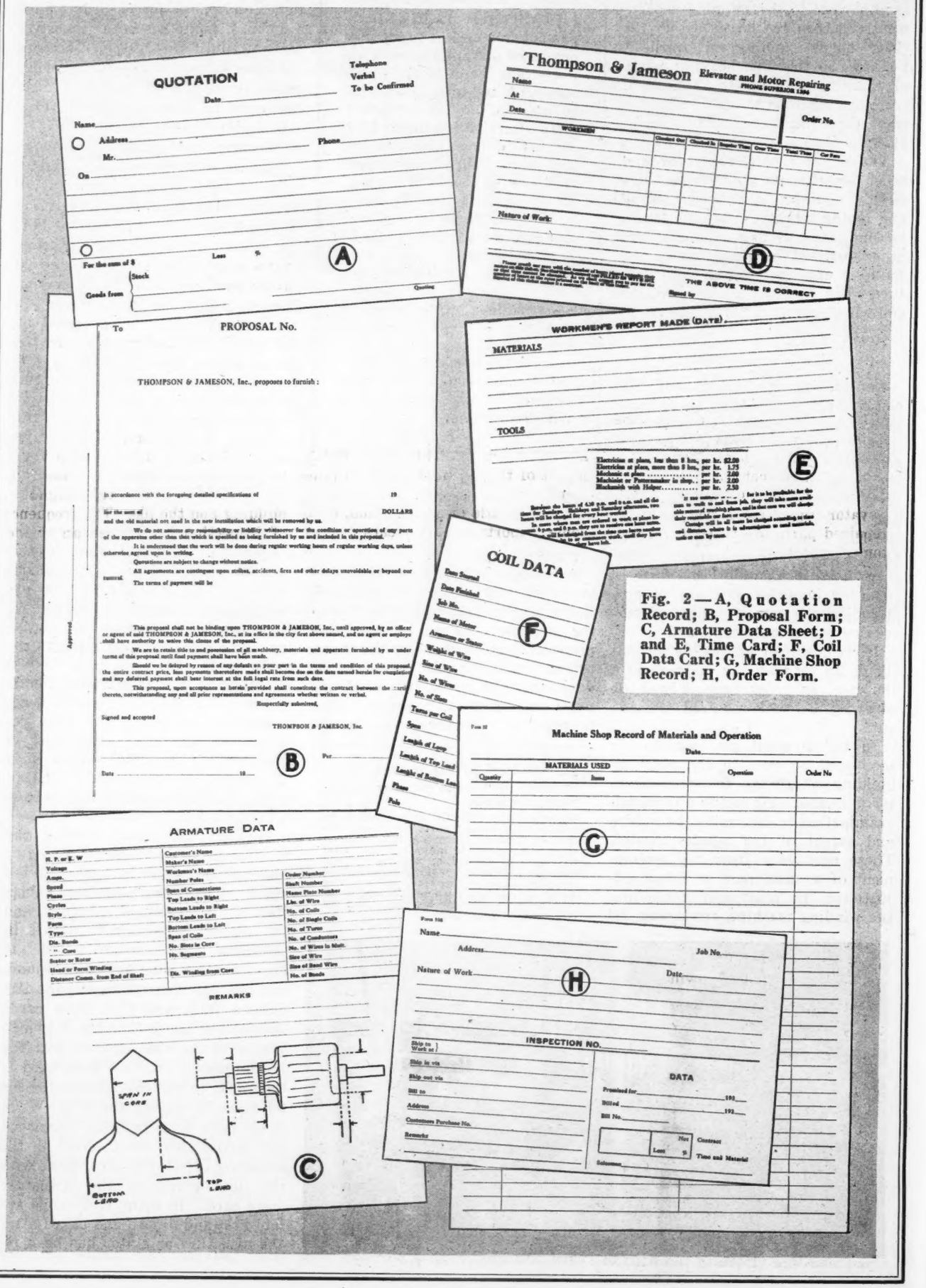


Fig. 2—A, Quotation Record; B, Proposal Form; C, Armature Data Sheet; D and E, Time Card; F, Coil Data Card; G, Machine Shop Record; H, Order Form.

wound. After the job is completed and the motor has satisfactorily passed the inspection tests, the cards are turned in to the office where they are filed under the proper job number.

The men who are working on the outside, for example overhauling or repairing an elevator, record their time on the tickets shown in Fig. 2 *D*; the back of these tickets is shown in Fig. 2 *E*. As will be noted, the customer is required to certify to the amount of time spent by our workmen while in the customer's plant. This not only gives us a check on our own men, but it precludes any possibility of dispute as to the number of hours spent on the job, a situation which is always unpleasant for everyone concerned.

The men in the shop enter their time on the ordinary form of job card, in which spaces are provided for entering the name of the workman, the date, job number, rate of pay, and time spent on each job.

When the shop work on, say, an elevator repair job is completed, the repaired parts are taken to the customer's premises and installed again. After the job is completed and the elevator has been turned over to the customer in satisfactory operating condition, all of the time and material tickets previously mentioned are turned in to the office where they are filed under the job number. The summary sheet shown in Fig. 6 is then made out from the data contained on the different tickets. This summary sheet shows, among other items, the nature of the work, the time spent by our workmen at the customer's plant and in our shop, the nature and amount of material used, and the profit or loss to us, on the job. This sheet is filed under the customer's name and furnishes a complete record of the whole transaction, so that if any question comes up later on, or we desire to know what was done and how much profit was made or loss incurred on a certain job, we have the information available at a moment's notice. These summary sheets are, of course, of the utmost value in helping us to prepare estimates of the cost of repair and other work.

Elevator Maintenance Service Insures Thorough Inspection

A very large percentage of the interruptions to elevator service result more or less directly from accidents due to carelessness, or neglect of the equipment. Lubrication of bearings and moving parts may be improperly done, at long intervals, or not at all. Bearings may be allowed to wear out without renewal at the proper time. Contacts may be allowed to arc and burn until little or nothing is left of them. In short, the equipment may be allowed to run as it will, with little or no attention, until some important part wears out or breaks and the whole machine is put out of commission; then an expensive repair or overhauling job may be required before service can be restored.

In plants or buildings where the amount of machinery in operation does not warrant hiring a competent maintenance man to take care of it the question of electric elevator maintenance is troublesome. The owner is confronted with the problem of either paying a stiff price for his elevator maintenance or else letting his equipment operate with little or no attention, but with the prospect of expensive interruptions to service and large repair bills, all of which may be still more costly in the long run. Usually one serious breakdown is enough to convince the owner that there is no economy in neglecting his equipment.

The logical solution of this problem is elevator maintenance service, which is an important part of our business. We employ a staff of men who are experienced in all branches of elevator maintenance and repair work and whose services are available to anyone who needs them. This service is furnished on the basis of a contract whose form is shown in Fig. 4 *E*. This form is, of course, made out in duplicate, one copy for our files and one for the customer. The terms of this contract are not at all burdensome; in fact it is nothing more than a written agreement between us and the customer whereby we agree to furnish certain services for a specified sum of money. The amount charged for this service varies according to the conditions, such as number and type of elevators, location in the building, height of building and the like. The frequency of inspection is likewise an important factor affecting the price. As a general statement, the contract price of our elevator inspection service varies from about $4 to $15 per elevator, according to the conditions and number of times inspected per month.

The contract is practically on a month-to-month basis, as it can be terminated by a written notice at any time by either party, although we reserve the right to complete the full month of service.

The contract specifies that a certain number of inspections of each elevator shall be made each month. This number also varies according to conditions: an electric elevator installed in a clean, dry place and where the conditions of service are not severe plainly does not require the same amount of attention that should be given to an installation in a very damp or dirty place and operated perhaps twenty-four hours a day. All of these points are taken into consideration when the contract is made and we use our own judgment, based on long experience, as

Fig. 3—The coil-winding section of the motor repair shop.

This department is equipped with coil-winding and taping machines, some of which are not shown here, capable of handling any size of armature, field, or stator coils likely to be encountered. The varnish dipping and baking equipment, which is designed to take complete stators and armatures or rotors, is located on the other side of the brick wall at the left.

Fig. 4—A and B, Installation Data Sheet; C, Elevator Specifications; D, Inspection Report; E, Inspection Contract; F, Motor Rental Contract.

to the frequency of inspection. As a rule, inspections are made at least once a month and usually not more than four times a month.

Inasmuch as we service many different makes and designs of electric elevators it is not practicable, or necessary, to specify in the contract all of the operations which are included under the head of inspection. These are lumped as cleaning, oiling, minor adjustments and inspection. As a matter of fact, however, our inspection may be briefly outlined as follows:

The motor is inspected first; this inspection consists in examining the commutator, brushes, brush holders and bearings, in a direct-current machine. In the case of an alternating-current motor, the bearings are inspected, the oil level noted, and the air gap between rotor and stator is checked. This is done by inserting in the air gap a flat piece of steel which is about No. 22 gauge, for general use.

Next the controller is inspected to see that all contacts are in good condition and all connections tight. The acceleration is tested to make sure that it is properly timed. All working parts are well oiled.

The elevator engine is then examined. The worm and drum bearings are tested to see that they are in good condition and properly lubricated. All bearings are oiled and the stuffing box on the worm shaft is looked over to see that it does not leak oil. The spokes in the drum are carefully gone over to see that

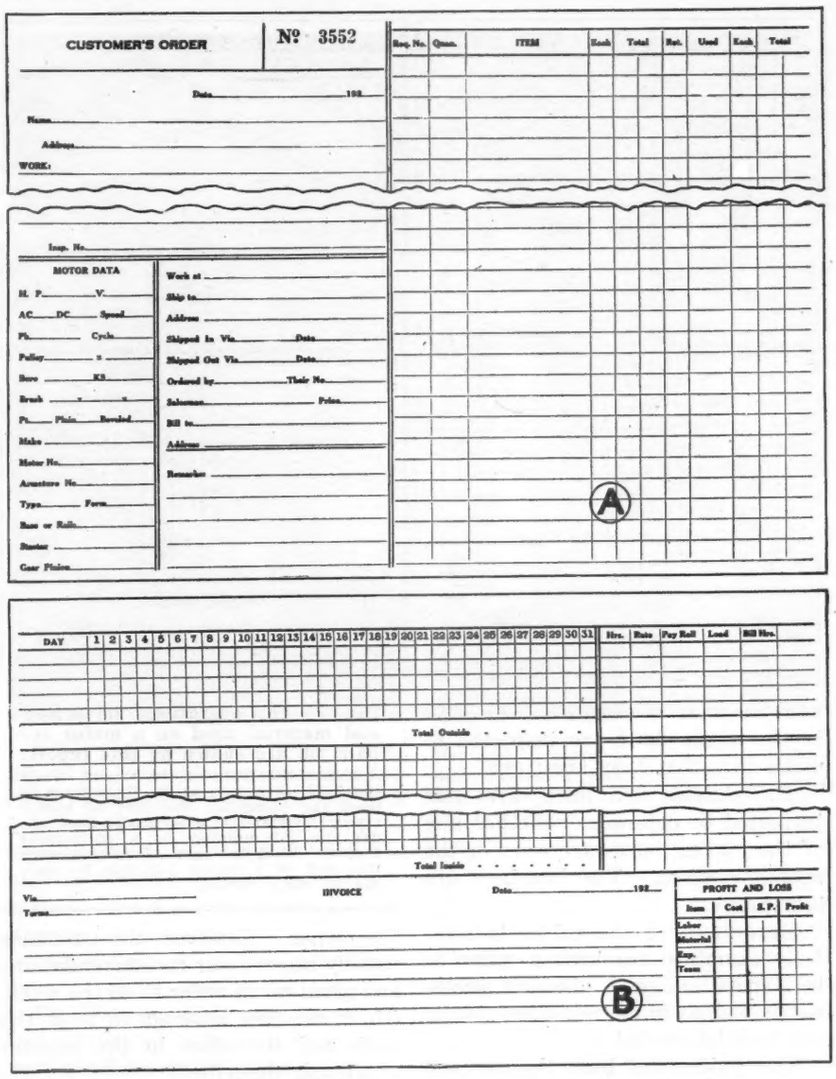
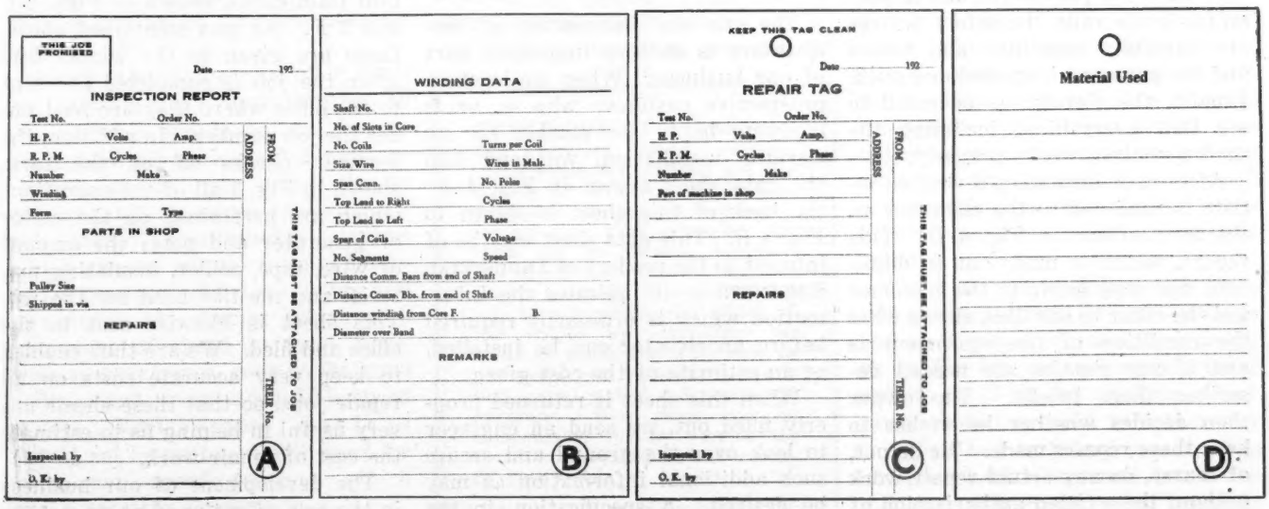


Fig. 5—These Inspection Report and Repair Tags serve to identify every job which comes into the shop.

A and *B* show the front and back, respectively, of the Inspection Report, while *C* and *D* show the front and back of the Repair Tag. When a motor or other part comes in for repairs these tags are attached to it and the part sent to the *Inspection Department*. Here the part is examined and the nature of the repairs noted on the Repair Tag. The inspector detaches the Inspection Report and holds it until the repairs have been made and the part returned for inspection and checking. When the part has been passed as satisfactory by the *Inspection Department*, these tags are sent to the office and filed under the job number.

Fig. 6—This summary sheet contains a complete record of every repair job.

When all of the time and material tickets and other records pertaining to a job have been turned in to the office this form is made out. It shows all of the data, including the profit or loss, that is likely to be required for purposes of record. This sheet is filed under the customer's name.



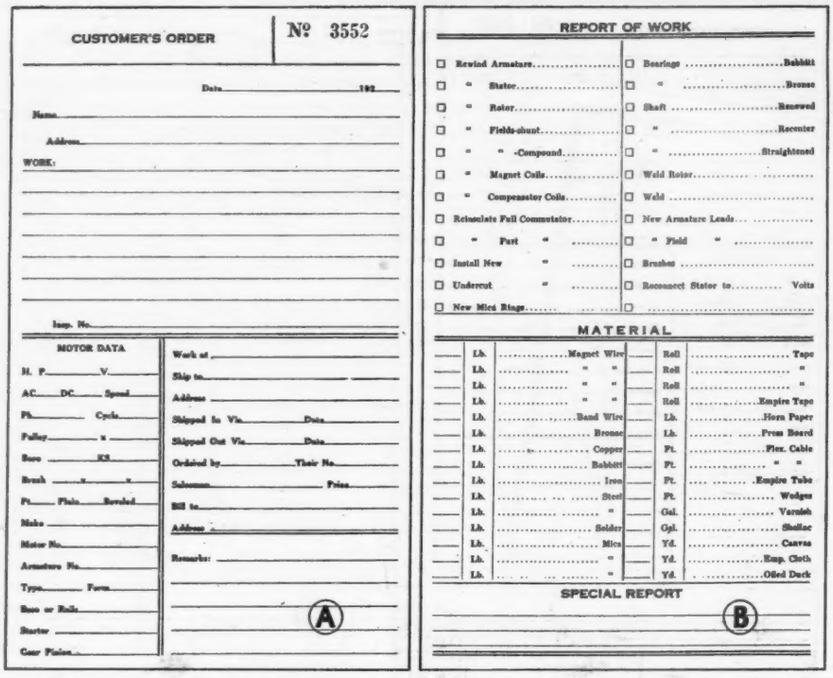


Fig. 7—The operations performed and material used on a motor repair job are shown on this report. *A* shows the front of the report, while the back is shown at *B*. This form is used for obtaining the cost of motor repair jobs and is afterwards filed under the job number as a permanent record. With the help of such records the cost of a repair job can be estimated very closely.

none of them is cracked. The keys in the drum shaft are inspected to make sure that they are tight.

The sheaves and idlers are next inspected to determine whether any of the journal boxes are worn or the spokes cracked. The bearings are lubricated.

Every foot of the cables is carefully examined for broken wires or bad spots and well oiled, if necessary. Cables in damp places usually are kept lubricated.

The guides for both the car and the counterweight are then inspected to see that they are properly lined up and firmly fastened. Also, they are well greased.

The car then receives attention. All bolts are looked over to make sure that they are tight; the shoes on the car are examined to see if they have the proper amount of play on the guide rails, the safety devices are carefully examined and tested and the governor inspected and oiled. Finally, the elevator is operated to see that everything, including the limit switches, works properly.

After each inspection a written report is rendered to the customer on the form shown in Fig. 4 *D*. This report, which is made out in duplicate, one copy going to the customer and the other to our files, shows what the condition of the equipment is and if any repairs are needed describes them briefly. The owner then decides whether he wishes to have these repairs made. We do not, of course, do any actual repair work without the written authorization of the owner. However, the customer usually accepts our recommendations and gives us an order to do the work, which is then handled in both the shop and the office in the manner previously described.

Incidentally, the fact that we have a number of men who spend most of their time on elevator inspection work makes it possible for us to put on an emergency job any number of men that may be needed.

Routine for Installation of New Elevators

The sale and installation of new elevators is another important part of our business. When we locate a prospective customer who is, or is likely to be in the market for an elevator installation, we send him the data sheet shown in Fig. 4 *A;* the back of this sheet is shown in Fig. 4 *B*. This data sheet may be of interest to the readers of INDUSTRIAL ENGINEER as it indicates the information which is ordinarily required before an elevator can be installed, or an estimate of the cost given.

When this sheet is returned properly filled out, we send an engineer to look over the ground and secure such additional information as may be desired. A specification, in the form shown in Fig. 4 *C*, is drawn up and submitted to the prospective customer. This specification covers all of the details of an installation including the duties and responsibilities of the customer, as well as our own, and gives the price and terms. In the event that our proposition is accepted, a job number is assigned for the installation and all time and material tickets and the like are charged to this number. When the job is completed these tickets are filed under the job number and a summary sheet, Fig. 6, is made out and likewise filed, so that we have on one sheet a complete record of the job, including the amount of profit or loss.

Although it was not the intention, when this company was first organized, to engage in the commercial repair of motors we were finally forced to do this. In order to take care of our elevator business properly, it was necessary to have a well-equipped motor repair shop, with experienced winders and other repair men who were capable of handling quickly and efficiently any burned-out or damaged motor which we would be called upon to repair. Burn-outs of elevator motors are not of such frequent occurrence that we could keep the motor repair department busy all of the time. In consequence, it was decided to extend our activities to include the repairing of motors or generators for anyone who wished to have such work done.

When a motor is sent in for repairs a Repair Tag, Fig. 5, bearing the job number, is attached to it and the motor given a thorough examination to determine just what is needed to put it in good condition. If it is a rewind job the foreman makes out the Armature Data and Coil Data cards, shown in Figs. 2 *C* and 2 *F*. As was mentioned above, these are given to the winder and after the job is completed are sent to the office where they are filed under the job number. In addition, the foreman checks off on the form shown in Fig. 7 all of the operations which are performed on the motor or generator and notes the amount of wire, tape, solder, insulating material and the like used for the job. This sheet is likewise sent to the office and filed. We are thus enabled to keep very accurate costs on all repair jobs, so that these sheets are very useful in helping us to estimate the cost of repair work.

The development of our business in the sale (*Continued on page 553*)

Some Practical Pointers on

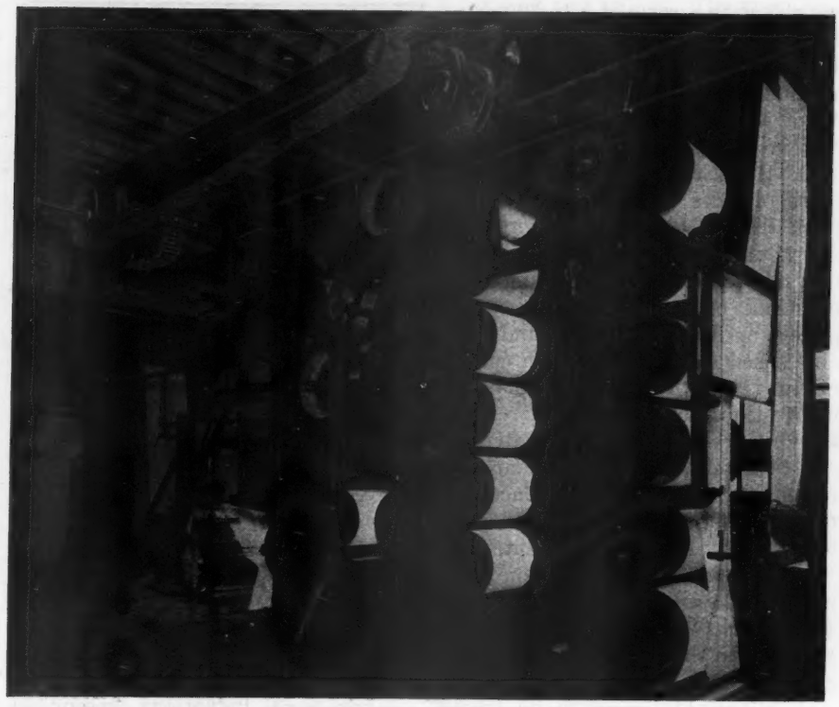
How Variable Speeds Can Be Obtained

For Adjusting the Speed to the Needs of a Process or to Work Performed by Machines Singly or in Groups in Industrial Plants

By FRANK E. GOODING
Associate Editor, Industrial Engineer

PRACTICALLY all production machinery may be operated to advantage at more than one speed. Many machines, however, could well be operated at a number of different speeds, particularly where different kinds of work are done on the same machine, or the process requires various applications. One example of this is in "filling" cloth in some textile processes. Many grades of cloth are filled after weaving. Ordinarily, the machine is provided with a driving pulley which will give the proper speed for the work requiring the slowest speed. Lighter weight cloth can be handled faster, but unless the pulley is changed or some other means provided for changing the speed, light work goes through as slowly as the heavier. An increase in speed would give a greater production with a consequent lowered cost.

Many other industries offer similar advantageous opportunities to use variable speeds as will be explained in this article. Different operating speeds may ordinarily be obtained for machines by (*a*) variable speed transmission devices which give an infinite ratio of increments between a fixed maximum and minimum; (*b*) devices which give increment of speed in fixed steps, such as gear boxes, gear shifts, cone pulleys and most adjustable-speed motors. Variable-speed devices should not be confused with spur- or worm-gear speed reducers which give a constant speed ratio.



Mechanical variable speed transmission with automatic control operating dryers and starch rolls at the Rockland Bleach and Dye Works.

This second type gives what might be termed a number of selections of constant speed instead of a true variable speed. This article, however, will deal largely with the first type which gives a more truly variable speed. This group in turn may be divided into:

(1) V-belts or pulleys, the diameters of which may be varied.

(2) Two parallel cone-shaped pulleys connected by a belt which may be shifted along the cones.

(3) Special hydraulic transmissions which give any increment of speed from nothing up to the speed of the driving mechanism.

(4) Sliding friction disks.

(5) Various special and complicated mechanical devices made up of sliding links, gears and other mechanical movements which can be varied over a definite range.

Probably, the most common of these types is the first which is known as the variable-speed transmission unit. This has a V-belt operating on a pair of pulleys, each of which consists of two cone-shaped disks mounted with the points of the disk turned toward each other, the tips of the cones forming the center of the pulley. The V-belt rests in the V formed between the two cones. Provision is made whereby one set of cones may be moved closer together which makes the belt ride higher on the pulley formed between the cones, while at the same time the other set of disks are moved farther apart, which makes that end of the belt ride lower between the two cones. This increases the diameter of one pulley as it decreases the diameter of the other and thus it varies the speed of the driven shaft. One pulley is connected with the driving motor of fixed speed or to a shaft and the other transmits power to the driven mechanism at a variable speed.

These are made either with plain self-oiling bearings or ball bearings and in a range of sizes in capacity up to 150 hp. by one manufacturer and up to 75 hp. by another. They range from the speed variation of 1 to 1½ up to 1 to 16 and over a range of speed both above and below the initial driven speed. For example,

WHERE OUTPUT depends upon the operating speed, variable-speed equipment enables the machinery to be driven at the best speed and also to be varied to suit conditions. For example, thin cloth can go through bleachers and driers more rapidly than can thicker material. Some of the factors in other industries which affect output by controlling the speed at which the work may be performed are: humidity, temperature, gage, quality and number of operators. How these may be compensated for by varying the speed is described in the accompanying article.

one size with a ratio of 1 to 10 variation is driven at 270 r.p.m. and will deliver any speed between 85 r.p.m. minimum and 850 r.p.m. maximum. All of these variations are not available in each of the sizes made, however. Sizes, ranges and capacities of these devices should be obtained from the manufacturer of any special equipment chosen. Higher ratios may be obtained by using combinations of more than one set of pulleys on both the driving and variable speed shafts. One such combination is shown in an accompanying illustration. It should be remembered, however, that the driving speed should not be greater than that recommended by the manufacturer. Otherwise, the load may go beyond the capacity of the equipment.

Variable-speed transmission units are used in a large variety of work. For example, they are often connected into the drive of an assembly conveyor in automobile factories to give a variable speed to its travel. Thus, if the output of cars is low for a certain day, fewer men, each with more work to do, are employed on the assembly line, and consequently the conveyor must move more slowly. If the production is to be increased, more men are put on the line and it is speeded up. Also, when beginning work in the morning, or after luncheon, the men start "cold" and require some time to get up to speed. After starting, the line may be speeded up a little at a time until it is finally up to full operating speed. The shifting mechanism may then be locked into position so that no unauthorized worker can slow it up. This enables the assembly line to be driven at all times at the best speed for the conditions, which may vary according to the quantity of output and also with different types or models. If the speed changes were not so easily made, much of this work would be done at a less effective speed.

In the Miller-Hurst power unit, which is used for driving assembly conveyors in a number of automobile plants, a constant-speed (usually a squirrel-cage induction) motor is connected to a Lewellen variable-speed transmission with a silent chain drive. The variable-speed shaft of the transmission is connected by chain to a Ganschow speed reducer, the low-speed end of which drives the conveyor. These are used in automobile assembly lines, as already explained, on body building conveyors, continuous drying and japanning ovens, and other similar work.

Where different types or weights of work go through a similar process is another place where variable speed is of advantage. For example, in galvanizing sheets, the continuous conveyor conducts the sheet through the furnace. The speed of travel depends upon the temperature of the furnace and the thickness of the sheets. The variable-speed devices give a close speed variation which can be quickly changed if conditions warrant. Veneer driers use a variable-speed mechanism in much the same way and for the same purpose, except that here the variation is necessary on account of different thicknesses of veneer and different woods used.

Bread bakeries, cake and biscuit plants make up an industry which offers the second largest opportunity to use these variable-speed devices. Many applications here are listed in the table on page 521. One example

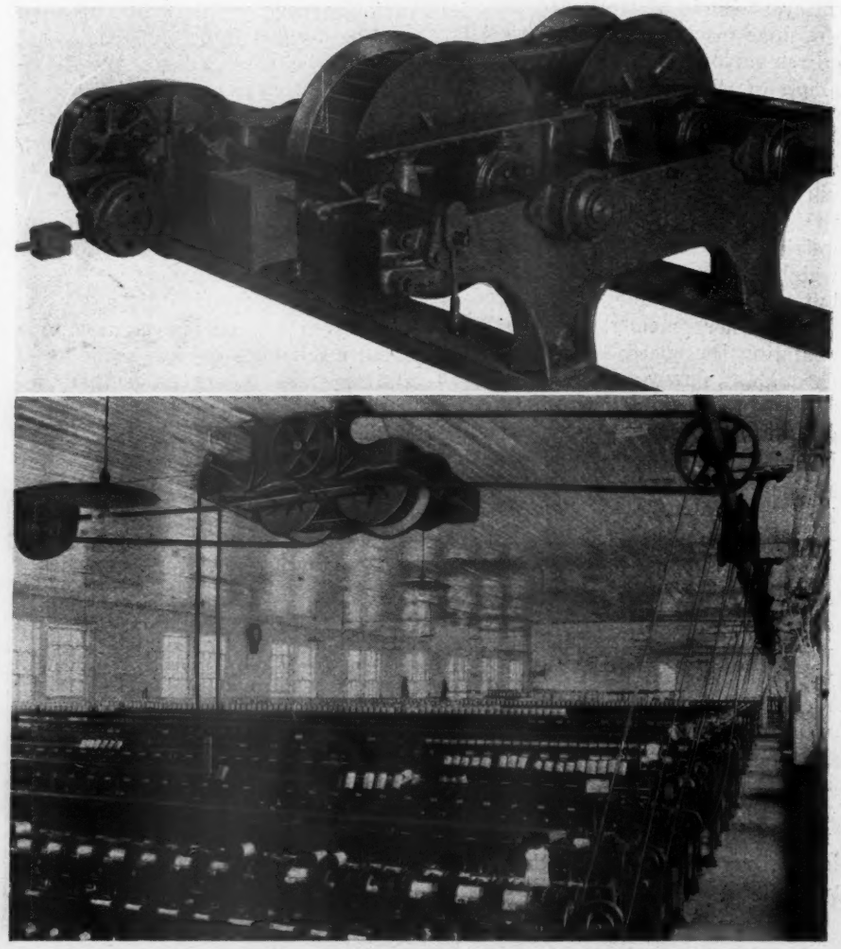
Factors Which Govern Proper Installation

Information the user must give to assure adequate equipment for the service conditions.

1—Kind of machine to be driven.
2—Diameter of machine driving pulley.
3—Width of belt on this pulley.
4—Fastest speed wanted on this pulley.
5—Slowest speed wanted on this pulley.
6—Speed of shaft from which transmission will be driven.

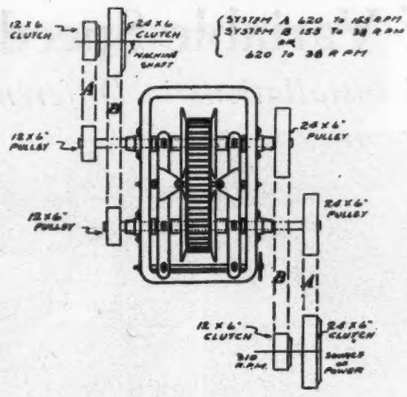
If an individual motor drive give the following additional information:

7—Horsepower rating of the motor.
8—Speed of motor.
9—Is motor to be connected by belt, chain or direct?
10—Diameter of pulley or sprocket on motor.
11—Width of belt on motor pulley or width and pitch of chain.



A detail of a variable-speed transmission and also an application in a textile mill.

The illustration at the top shows a complete ball bearing, Lewellen variable-speed transmission with automatically controlled motor, safety stop, demountable screw bearings and other features. In this case the V-shaped belt connecting the two pulleys is set at about a 1 to 1 ratio. As the diameters of the pulleys are changed by moving the cone-shaped disks farther apart or closer together the ratio is changed. The automatic shifting mechanism is shown at the left end. The lower illustration shows an application of a Reeves variable-speed drive in a silk mill.



One method of obtaining high ratios through the use of clutches and more than one pair of pulleys.

This indicates two systems of transmitting power to get high ratios. On line-shaft or other source of power is mounted two clutches and pulleys, 24 in. x. 6 in. and 12 in. x 6 in. While the 24-in. x 6-in. clutch through system *A* is driving, the 12-in. x 6-in. clutch on system *B* is floating and the 24-in. x 6-in. clutch on the machine to be driven is also floating, while the 12-in. x 6-in. clutch is engaged. In other words, while system *A* is engaged entirely, system *B* is floating. Following through system *A* starting at 310 r.p.m. on line shaft, it turns shaft on machine to be driven from 620 to 155 r.p.m. When this limit is reached then system *B* is brought into engagement and immediately thereafter system *A* is released. This then carries the transmission on to further reduction and the speed of 38 r.p.m. is reached on the machine, or, in other words, variation of from 620 to 38 r.p.m. may be obtained through this double system of clutches and pulleys.

shows the advantages obtained. The time of baking different cakes and biscuits (cookies or crackers) varies with the kind and thickness. Obviously, an attachment which will vary the speed of the conveyors in the continuous ovens to fit the varying products would be of advantage, and not only increase output but the quality of the goods. The same is true of icing trolleys and cooling conveyors.

The possibility of greatest use of variable speeds probably lies in the textile industry. How these have been used in "filling" has already been mentioned. In a silk mill, for example, the installation of variable-speed transmissions to the throwing frames resulted in a reduction of 80 per cent in the number of the broken fibers. Now the throwing machines are started up at 1/10 of the operating speed and gradually are thrown into full speed by the variable-speed equipment. Before stopping, the machine is run down to its lowest speed. It is in the starting and stopping process that the most of these fibers are broken. This machine alone eliminated about 75 per cent of these breakages and with the addition of a fly-wheel to give it a more even operation, an additional 5 per cent was gained. The manufacturer estimates that these machines pay for themselves every sixty days and now has twenty-six installed.

Space will not permit of an extended explanation of each application included in the list below. Those familiar with the processes in the industries listed can understand the value of a variable speed instead of a fixed or stepped speed if they but bear in mind the following general characteristics of this equipment in relation to the work or process: (1) Progressive conveyors or machines handling various types, gages, weights, quantities or products. (2) Where it is necessary or desirable to start in slowly and work up to a higher speed, or to reverse the process in stopping. (3) Where the speed of the machine depends upon some other machine or process.

Stoker feeds, governor control of variable-speed engines and machines operating in tandem are common examples of this third application. Operation of machines of this third type has led to the development of automatic and remote control for the variable speeds. For example, stokers are controlled by the boiler pressure. Blowing and other variable-speed engines are also controlled through the governor by the pressure.

Machines in tandem are usually controlled by the process. For example, illustrations *F* and *G*, page 522, show how a rope-reeling frame is controlled by the slack between the rope machine and the reel. The reel speed thus slows up automatically as the diameter of the coil increases. Sometimes tandem machines are controlled mechanically as by the floating roll on the textile machine shown as *E*, page 522, and in the sketch on page 524.

Many automatic and remote controls of variable-speed transmissions are used on textile machines, paper mills, wire and rope machines, biscuit machines and others operated in tandem. Remote control may be provided so that the different machines may be controlled by push buttons in several locations. Indicating and recording tachometers are commonly used in connection with remote control. With hand control where tachometers are not used, an indicating scale may be so placed as to show the speed for any position of the hand wheel. One of the big advantages of remote control lies in the ease with which the speed can be changed. If the worker can vary the

Some of the More Common Industrial Applications of Variable-Speed Transmissions

Bakeries and Biscuit Plants—For driving cutting machines, dough mixers, icing and marshmallow beaters, wafer machines, icing trolleys, cracker cooling conveyors, cracker machines, pan elevators, depositing machines, horizontal and vertical ovens, cone machines, pretzel machines, embossing machines, soft cake machines and other equipment.

Canneries—For driving can fillers, cappers, pea viners, blanchers, exhausters, bottling machines, elevators and conveyors.

Rubber Mills—Coating, wrapping and tubing machines, bias shears, strippers, conveyors.

Laundries—Flat piece ironers, centrifugal wringers.

Machine Shops—For driving planers, boring mills, shapers.

Cement Mills—For driving kilns, coal feeders, conveyors.

Paper Mills—For driving fourdrinier machines, cylinder machines, winders, cutters, engine governors, pumps, calenders, coating machines.

Wire Mills—For driving drawing, galvanizing, coiling, insulating, fence loom, screen japaning, steel cable and armored conduit machines.

Mining—Ore crushers, concentrators, conveyors, sintering frames.

Power Plants—Stokers, pumps, fans.

Veneer Mills—Lathes, dryers.

Textile Mills—For driving tenter frames, dryers, washing machines, moisteners, mangles, starching and printing machines, singers, mercerizers, silk throwers, winders.

Paper Box Factories—Corrugators, double enders, double backers, pasting machines, creasing machines, cutters, slotters, printing presses.

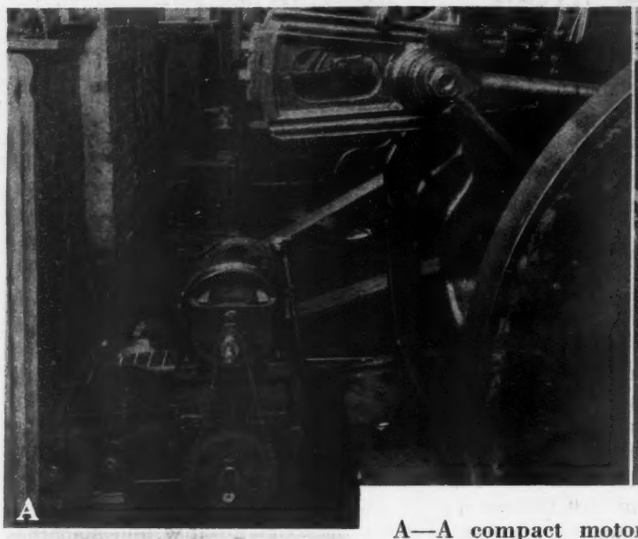
Packing Plants—Hog and cattle rails, viscera and cutting tables, steam tables, conveyors, butterine rolls, dehairing machines.

Automobile Factories—Assembly conveyors, tempering furnaces, elevators, enameling ovens.

Miscellaneous Machines—Envelope machines, oil agitators, rotary ovens, wall paper machines, match making machines, clay working machines, sugar granulators, glue cookers, glue spreaders, candy machinery, printing presses, excelsior machinery, paint grinders, paper coating machines, crayon presses, soap presses, crepe paper and roofing paper machines, some chemical processes and any others on which speed regulation is desired.

Applications of Variable-Speed Transmissions

Ten Typical Installations in Different Industries



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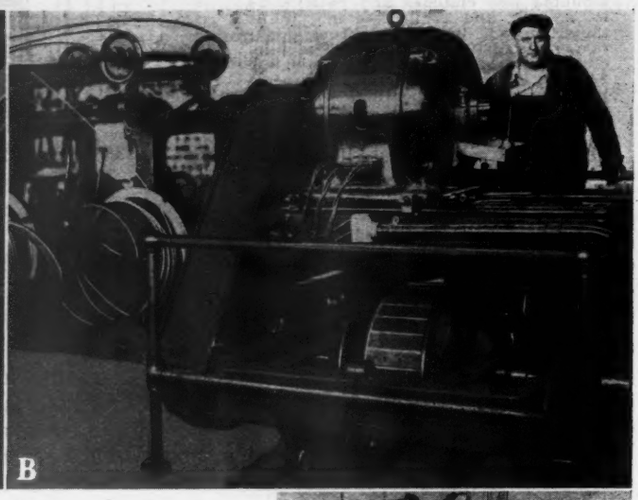

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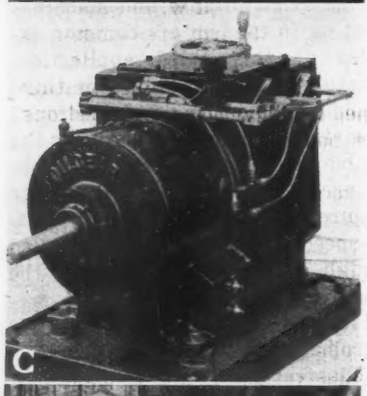

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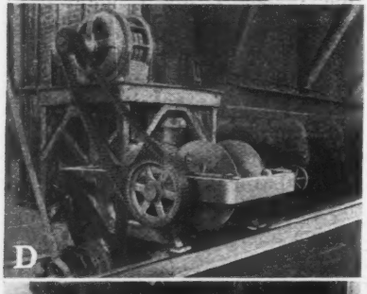

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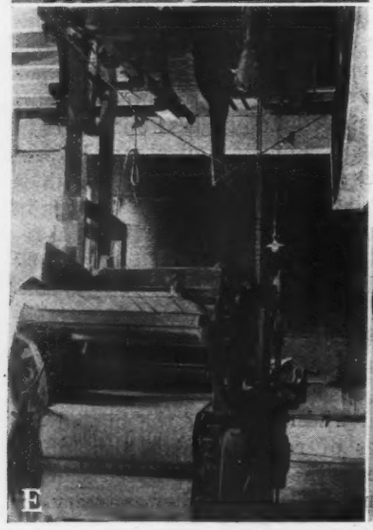

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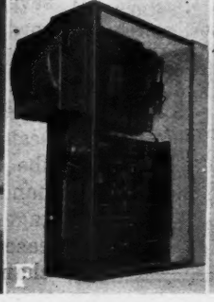
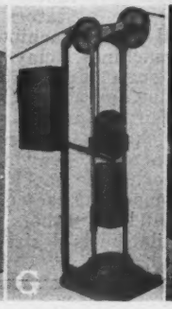


F



G

A—A compact motor drive operating a platen printing press through a variable-speed transmission unit.

B—Variable speed enables each gage of wire to go through the galvanizing process at the proper speed.

C—The drive end of one type of hydraulic variable-speed transmission which will give any speed from zero to the input speed.

D—Automatic control of the feeding speed by changes in boiler pressure may be applied to variable-speed stoker drives.

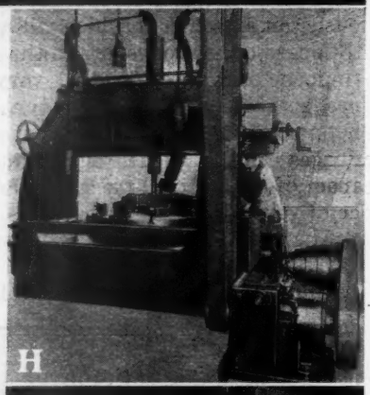
E—An installation of a variable-speed control on a biscuit machine.

F and G—The slack of the rope between a rope machine and the reel controls the variable-speed unit through the electrical equipment in the box (F) and automatically maintains the reel at the proper winding speed.

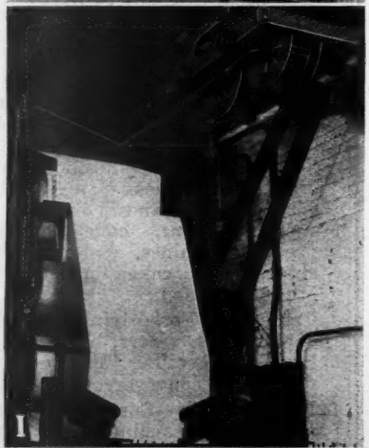
H—Hydraulic variable-transmission application on a boring mill.

I—This floating roll and counterweight automatically shift the variable-speed lever on this tentering frame in a textile mill.

J—A manually-controlled, variable-speed drive regulates the operation of a traveling bread oven.

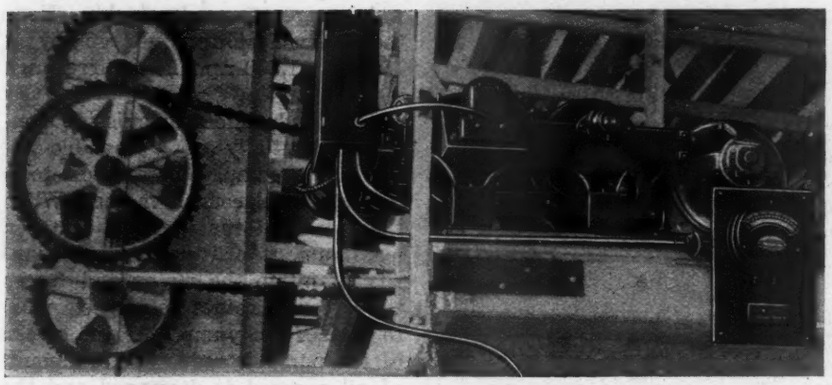


H



I

J



An installation of a variable-speed control in a bakery.

Here a variable-speed transmission operates a bread cooler and proofer. This has push button control and an electric indicating tachometer. In installations where the machines are on different floors control panels are located on each floor together with an indicating tachometer on each panel. In this way, an operator on any floor knows the exact running speed at all times and the arrangement is such that the speed can be controlled from any floor at any time. In some cases indicating tachometers are located on the oven or other machines and recording tachometers placed in the office.

speed from any of a number of positions by pushing a button he is more likely to do so than if he has to walk to the other end of the machine and turn a crank. Where they have been installed it has been found that the operators actually use them.

Some of the advantages which are claimed for the mechanical variable-speed transmission are: (1) Minute adjustment over the variable range both above and below the driving speed. (2) High ratios of speed changes; machines of the different capacities can be obtained in a number of classes which give from a ratio of 1 to 1½ up to about 1 to 8 or 10 and in some sizes up to 1 to 16. (3) The horsepower-variation ratio is less than the speed-variation ratio between their maximum and minimum. For example, on a speed variation of 1 to 12, the horsepower variation may be in the ratio of approximately 1 to 4½. (4) The speed is easily changed by hand, automatically or by remote control. (5) The device may be installed on the ceiling, on the floor, or on the wall. (6) It may be connected to the most efficient type of motor, to a lineshaft, or to any other driving mechanism. (7) The mechanism is simple, easily installed and maintained.

Ordinarily, this type of variable-speed transmission is not used on machine tools as generally these tools are provided with a number of speed changes and means as through the cone pulley or through the gearing which will give sufficient steps to get any desired speed. They could probably be used to advantage, however, on boring mills or on large lathes which are doing a great deal of facing work across pieces of large diameter, as they could be arranged to maintain a constant speed at the cutting edge of the tool irrespective of the change in diameter of the parts faced. These variable-speed devices have been used on metal planers by attaching the quick-return drive belt to the constant-speed shaft of the variable drive, and the cutting or driving belt to the variable-speed shaft. This enables a quick return to be obtained without using a pulley of large diameter and also gives a varying speed for the cutting tool.

It is well to consult with the manufacturer in determining upon a variable-speed transmission. He can base his advice on the information obtained in response to the questions in the box on page 520. Although this is a sturdy piece of equipment, and practically everlasting in the ball-bearing type, there are still some points which require consideration, as does all mechanism. Ball bearings need oiling only once or twice a year, depending upon the service conditions. Transmissions with self-oiling bearings require more frequent attention. Dust or abrasives do not have any appreciable effect upon the drive as they are jolted or fall off the cone-shaped pulley. However, if oil or grease are left on the cones, the dust sticks and becomes somewhat more abrasive. Careful oiling will prevent this. Also, oil on the

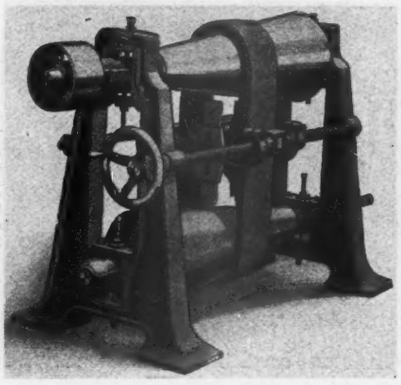
Applications of a variable-speed transmission unit in an automobile body plant and in a laundry.

In the automobile body plant at the left a Reeves variable-speed transmission is connected into a Palmer-Bee conveyor system. This is used to give a variation in the control of the speed for different production output. The illustration at the right shows an application on a flat-piece ironer in an Indianapolis laundry. It enables a laundry worker to get the most out of the ironer by allowing her to select quickly the speed best adapted to the classes of work which go through. Some work obviously requires slower, more careful handling and, if thicker, more heat, while other work can go through much more rapidly.

rubber belt holding the V-blocks rapidly deteriorates it. This also may be prevented with care. Do not try to change the speed adjustments by shifting the disks while the drive is standing still.

Where it is necessary that variable-speed transmissions operate in hot locations, the V-block may be attached to a steel or chain belt which is not affected by the heat or other conditions. In some industries, such as in canning plants, where the drives are used only for a short time during the season, the manufacturers recommend that the main shafts and other bright parts receive a good coating of grease when the machinery is shut down for the idle period so that it may be put into shape quickly and easily at the beginning of the next season.

On transmissions in which a pair of cone pulleys are connected by a belt, as is illustrated at the top of the page, special belts are used. Here special short, endless belts made up of wedge-shaped leather blocks fastened to the inside of another belt are placed around each pulley. The driving belt, which goes around on the outside of the two short belts, rests on parallel surfaces and is not twisted as it would be if it rested directly upon the two cones. Another type of two-cone, variable-speed transmission has the pulleys close together and a short endless belt around one of them. The power is transmitted through the pressure applied to the belt which is moved along the length of the two conical pulleys and gives the varying speed. Some types of two-cone, variable-speed drives are connected by belts which may be shifted. Because the two faces are not parallel this type works better with the belt crossed. One type which is sometimes used consists of a narrow belt next to the two pulleys which has riveted to it, on the outside, another, somewhat wider belt to receive the wear of the shifting device. These are frequently used in place of countershaft drive in machinery and in the larger sizes in some of the same types of work on which mechanical variable-speed devices are used.



A special type of taper cone variable-speed drive.

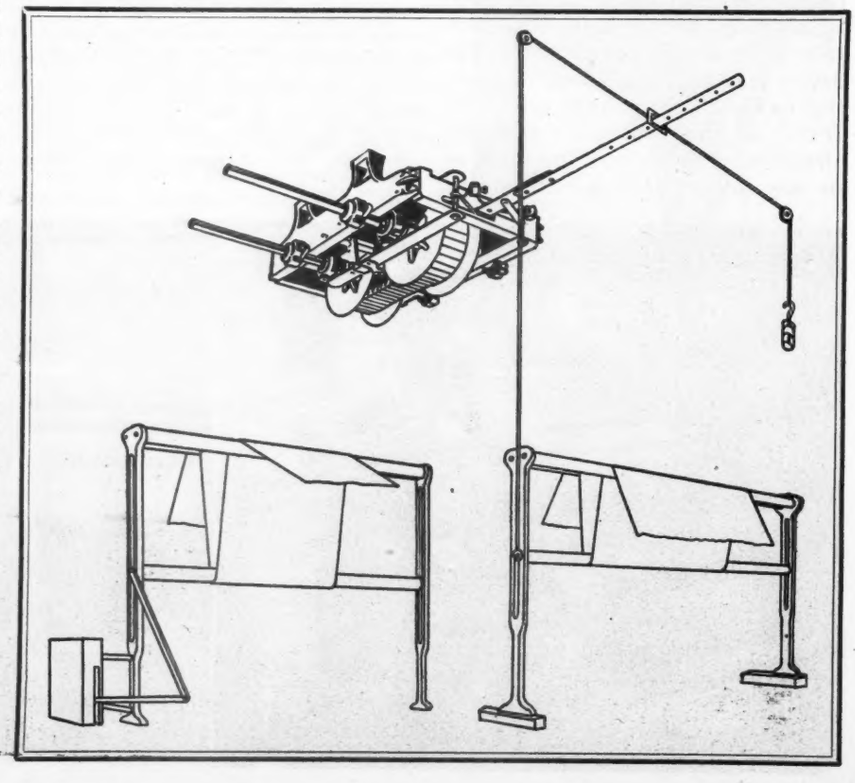
One of the principal difficulties in applying a belt to a drive of this sort is due to the taper of the cones. The feature of this speed changer is in the method by which a level bearing surface is provided for the belt. This is obtained here by means of patented cone pulley transformers which consist of a series of tapered leather strips riveted to short, endless belts, one of which is placed around each cone. These provide parallel pulley surfaces, for the driving belt. The speed changes are made by shifting the belt by the mechanism shown.

One Type of Hydraulic Variable Speed Transmission

One type of variable-speed hydraulic power transmission is shown in illustrations *C* and *H* on page 522. In another case it was connected to a lathe used in turning elevator sheaves in place of the cone pulley to give a wide range of speeds quickly. Here the transmission is driven by a 7½-hp., 1,800-r.p.m., squirrel-cage motor.

This hydraulic transmission consists essentially of a variable-displacement pump, pumping oil to a constant-displacement motor. When the stroke of the pump is set at a maximum, it delivers a fixed quantity of oil to the motor and forces the latter to rotate at a speed equal to that of the pump. As the stroke of the pump is reduced, the amount of oil pumped is decreased and the motor will rotate more slowly. Any speed of the driven shaft may be obtained from zero up to the speed of the original driving shaft by merely changing the stroke of the pump. This can be done by ropes on pulleys or by an extended hand wheel which is placed within reach of the machine operator. This device is claimed to deliver an even torque throughout the reduction. It is put out in two sizes, one rated at from 10 to 15 hp., and the other from 5 to 7½ hp. capacity. It is designed primarily for use in driving lathes, boring mills, cranes, paper mill machinery and other equipment where variable speed or instant control is desirable.

The fourth type of variable-speed devices, those with friction units, are used with more or less success in some kinds of work. For example, some types of light friction drill presses use (*Continued on page 555*)



Examples of mechanical and automatic control of variable-speed transmission units.

In the illustration at the right, the operating or shifting lever is controlled by the floating roll through a cable or a chain. The shifting screw is omitted and the speed is controlled by the lever and determined by the position of the floating roll. The small illustration at the left shows the method of controlling the speed electrically through a floating roll. The electrical control is also used where the variable-speed transmission is too far from the roll to be operated mechanically.

Here Are Some Easy Ways of

Identifying Pipe Lines And Valves

In Industrial Plants Together With Records That Simplify Tracing, Installation, Maintenance and Repair of This Equipment

By DAVID FLIEGELMAN
Chain Design Division, American Chain Co., Bridgeport, Conn.

This shows how easily the black letters on the white background of the valve tags may be read from a distance.

PRACTICALLY all industrial men have had experience in tracing out pipe lines or hunting for valves which cut off a section so that changes or additions may be made or other work done on the line. If the lines or valves are without means of identification there is always danger of making an error with possible disastrous results. While many factories have a partial scheme of identifying pipe lines it would be worth while carrying it on throughout the plant. One complete color scheme which has worked out satisfactorily in several instances is given in an accompanying table. Where a system is already partially identified according to another scheme this may be modified to suit the work already installed.

The fire lines include the sprinkler system, indicator post valves and firehose connections. Live steam piping is usually covered to prevent loss of heat by radiation and as these coverings are usually white they fall in with the above color scheme. The paint used should be especially adapted for the purpose.

Copies of the adopted code should be furnished to all those interested in order to get them acquainted with the colors and their significance. It is naturally understood that only the exposed piping is painted. Not only do the painted pipe lines make a neater appearance, but they assist in following up a certain line when necessary, or in identifying a certain line when a new connection or branch is to be added.

Supplementing the scheme of painting the pipe lines according to some adopted code, all valves should be tagged. In one plant, valves above ground carry a 15-gage sheet metal plate of the dimensions shown in the sketch; the letters are 1¾-in. high and the plates are painted white all over. The numbers are painted in black, which allows them to be seen across the room. The illustration at the heading of this article is of a photograph of two valves suitably tagged. The tags are wired to the valves in such a manner that the numbers can be readily seen by one looking for them. Care must be taken, however, to see that the tags are placed so that they do not interfere with operating the valve.

Valves located in pits or tunnels carry small brass tags ¾-in x 2-in., similar to those used in tagging machines, upon which the valve numbers are stamped.

One Method of Identifying Pipe Lines

Fire Lines	Red
Hot Water	Light Green
Cold Water	Dark Green
Drains	Blue
Live Steam	White
Steam Returns	Brown
Heating Lines	Black
Gas	Yellow
Oil	Drab

The method employed in numbering the valves makes use of a letter in conjunction with a number to help identify it. All valves on fire lines are lettered *F*; on hot water lines *H*; on cold water lines *W*; on live steam lines *S*; on steam return lines *R*; on gas lines *G*; and on oil lines *O*. In this way the code letter assists in identifying any pipe line by indicating its purpose. This system of identifying the valves can be used even though the pipe lines are not painted according to any prescribed code. For that matter, a simple system of identifying the valves is even more necessary and valuable when the pipe lines are not coded.

The valves are numbered in order, as far as possible. For example, the main valve controlling the cold-water supply to all the factory buildings, is tagged *W-1;* then come the valves controlling the water supply to each building, as *W-2*, *W-3*, and *W-4*. The cold-water valves in each building are then tagged in rotation. The same method of numbering can be applied to the other valves on the gas, steam, hot water and other lines.

After the valves are tagged, valve service sheets are gotten up in blueprint or printed form, so that sufficient copies can be made for distribution. These sheets tell at a glance

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W-16 - 1½" Valve, located in basement Bldg. "A", in front of toilets. Together with W-24 controls cold water supply to all toilets and washstands in Bldg. "A".

W-17 - 1" Valve, located in Bsmt. Bldg. "A" (about 20 ft.east of toilets). Controls cold water supply to Welding Machines in Dept. 7 (2nd floor, Bldg. "A".)

W-18 - 2" Valve, located in Bsmt. Bldg. "A" (opposite Bldg. "C"). Controls cold water supply to Bldg."C" and part of cold water supply to Bldg. "L".

W-19 - 2" Valve, located in Bsmt. Bldg. "C", in front of toilets. Controls cold water supply to washbasins in Bldg. "C".

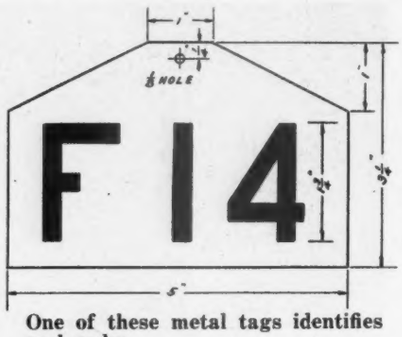
W-20 - 1" Valve, located in Bsmt. Bldg. "C", in front of toilets. Controls cold water supply to factory office washrooms on 2nd floor Bldg. "C" and also to drinking fountains near Elev. #8 on all floors in Bldg. "C".

One page of the loose-leaf valve record.

This valve record contains complete information about each valve such as: its number, location, size, function and, if a special valve, when to be opened or closed and by whom. The key valve controlling each department is found by consulting the valve service chart shown in an accompanying illustration.

the various valves that control the cold water, hot water, steam, and other lines on each floor or in each department. A sample sheet is shown in one of the accompanying illustrations.

The service sheets are supplemented by 3½ by 6-in. loose-leaf notebooks. These books contain complete information covering all valves,



One of these metal tags identifies each valve.

such as: (1) valve number, (2) location, (3) size, (4) function and, if a special service valve, (5) when to be opened or closed, and (6) by whom. Complete copies of these notebooks are furnished to the works manager, factory superintendent, factory engineer, boss piper, and night watchman. The copies supplied to the foremen include only the valves which are of interest to them, so that should there be a leak or break in any of the lines on their floor or in their department, the foreman or the assistant foreman will know what valve to close and exactly where it is located.

If a sprinkler head accidentally opens, it is advisable to shut off the water supply as soon as possible to minimize the damage done by the water. To facilitate this and to acquaint everyone with the location of the post indicator valve controlling the sprinkler system on each floor or in each department, one or more "sprinkler" cards should be posted conspicuously in every room. A sample card is shown herewith. I believe this card is more effective when lettered in red. These cards can be framed or given a coating of white shellac which protects the surface from soiling and keeps the printing from fading.

Sprinklers

In case a Sprinkler Head in this room breaks, shut off Indicator Post Valve.

No. F 11

Located in yard on *east* side of this building.

Also open drain pipe valve

No. F 110

Located in basement of this building.

Much water damage may be prevented if notices like this are placed conspicuously.

Some valves are to be opened only by certain people in authority. These valves are usually in the sprinkler system and in the live-steam lines in the boiler room. Such valves are usually kept open, but when necessary to close one of them in case of repair, a red paper tag is attached to the valve, giving the following data: (1) when closed, (2) why closed, (3) by whom, and (4) for how long. A duplicate red tag is filled out and is sent immediately to the superintendent's office.

When repairs are made and the valve in question is opened, its tag is removed. A green tag, giving the additional information relative to the re-opening of the valve, is sent to the superintendent who files it away with the red tag previously sent him. These green and red tags are usually furnished by the insurance companies.

VALVE SERVICE

BUILDING	FLOOR	DEPT. NO.	SPRINKLERS	COLD WATER	HOT WATER	H.P. STEAM	H.P. RETURNS	L.P. STEAM	L.P. RETURNS	TOILETS	FOUNTAINS	WASHBOWLS	GAS	
A	Bsmt.	5	F-6		H-7			S-25	R-2	W-16	W-24	W-16		
A	1st.	5	F-6		H-7			S-25	R-2	W-16	W-24	W-16		
A	2nd.	7	F-6		H-7			S-25	R-2	W-16	W-24	W-16		
A	3rd.	17	F-6		H-7			S-25	R-2	W-16	W-24	W-16		
A	3rd.	14	F-6		H-7			S-25	R-2	W-16	W-24	W-16	G-6	
B	Bsmt.	5	F-3		H-7			S-23	R-3			W-12		
B	Bsmt.	16	F-3					S-23	R-3				G-4	
B	1st.	1	F-3					S-24	R-4	W-12	W-13			
B	1st.	2	F-3					S-24	R-4	W-12	W-13		G-4	
B	1st.	3	F-3					S-24	R-4	W-12	W-13	W-12		
C	Bsmt.	5	F-11		H-5			S-27	R-2	W-21	W-20	W-19		
C	Bsmt.	15	F-11		H-5			S-27	R-2	W-21	W-20	W-19		
C	1st.	5	F-11		H-5			S-28	R-3	W-21	W-20	W-19		
C	1st.	7	F-11		H-5			S-28	R-3	W-21	W-20	W-19		
C	1st.	9	F-11		H-5			S-28	R-3	W-21	W-20	W-19		
D	1st.	12	F-10	W-31	H-4	S-10				W-28				
K	1st.	22	F-14	W-33	H-3	S-32			R-3	W-34	W-47	W-34	G-2	
L	1st.	21	F-7	W-41		S-36	R-5	S-16	R-5				G-5	

Valve service sheets such as this are made out for every valve.

This chart shows the valves which control the water, gas, steam and other feed lines in each of the various buildings and departments. In other words they are the key valves. A glance at this chart shows the valve wanted. The exact location of that valve is given in a loose-leaf notebook a sample page of which is shown in one of the accompanying illustrations.

SHOULD THE SMALL hoist be hand operated or motor driven? If it is to be motor driven, should a series-wound, direct-current, or a squirrel-cage, alternating-current motor be used? Should a manual controller be selected, or is a magnetic controller justified? How many and what kind of brakes should be specified? What overtravel limits should be provided? What features should the different parts of the hoist have to insure low maintenance and satisfactory operation? In this article Mr. Hunter answers these questions and many more concerning the operation of small hoists.

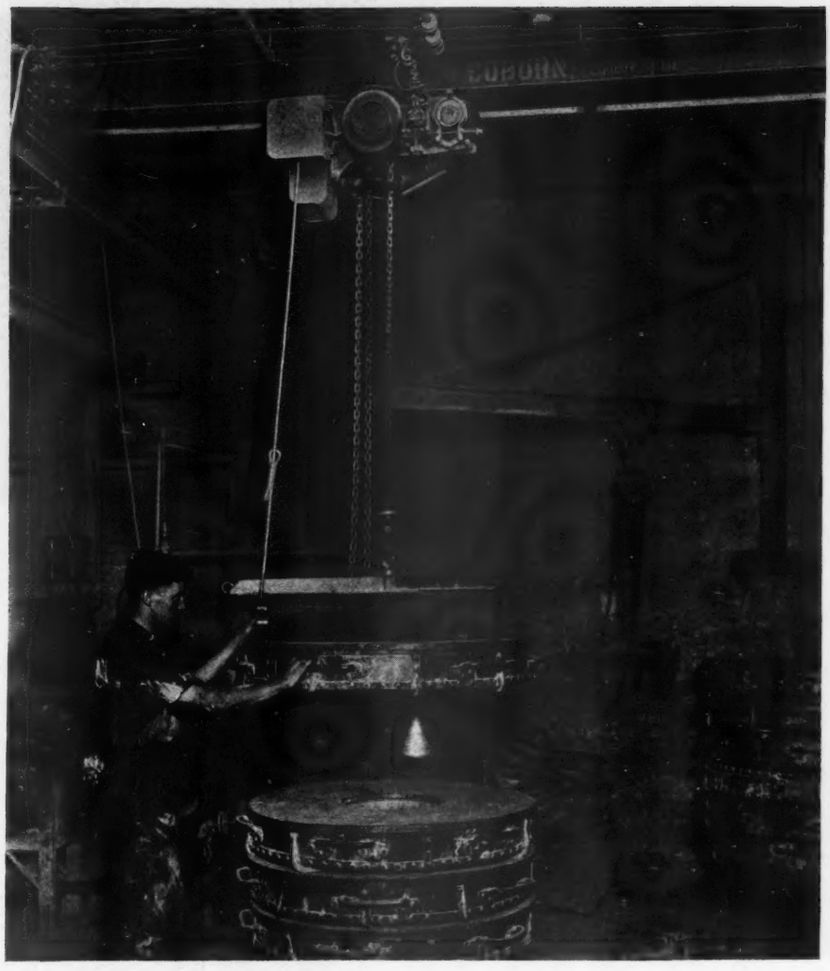
Things It Pays to Know About the

Operation and Selection of Small Hoists

Together With the Types and Operating Features of the Control, Brakes and Overtravel Protection

By R. B. HUNTER

Electrical Engineer, The Cutler-Hammer Manufacturing Co., Milwaukee, Wis.



This small hoist has a magnetic controller which is operated from the push-button switch in the operator's hand. A close-up view, showing the details of the hoist is given at A on page 528.

THE MODERN successor to the chain block, is the electric hoist in ½-ton to 2-ton capacities. While the factors which justify the larger investment may be quite varied, there is always one underlying reason for the choice of the electric hoist. This is the human factor; man power is multiplied by its use and men can be selected on a basis other than brawn. For this reason, in selecting a hoist, careful consideration should be given to all the parts that make up the hoist, and in particular to the control, which is the link between the operator and the hoist, and between the hoist and the source of power.

The elements of the electric hoist are: (1) the suspension; (2) the motor; (3) the gear reduction between the motor and (4) the winding drum, on which is wound (5) the chain or cable terminating in the hook or other load-supporting device; (6) the control; (7) a brake to retard the load during lowering and to hold it suspended; (8) a brake to stop the motor; and (9) a stop to prevent overtravel of the hook and block.

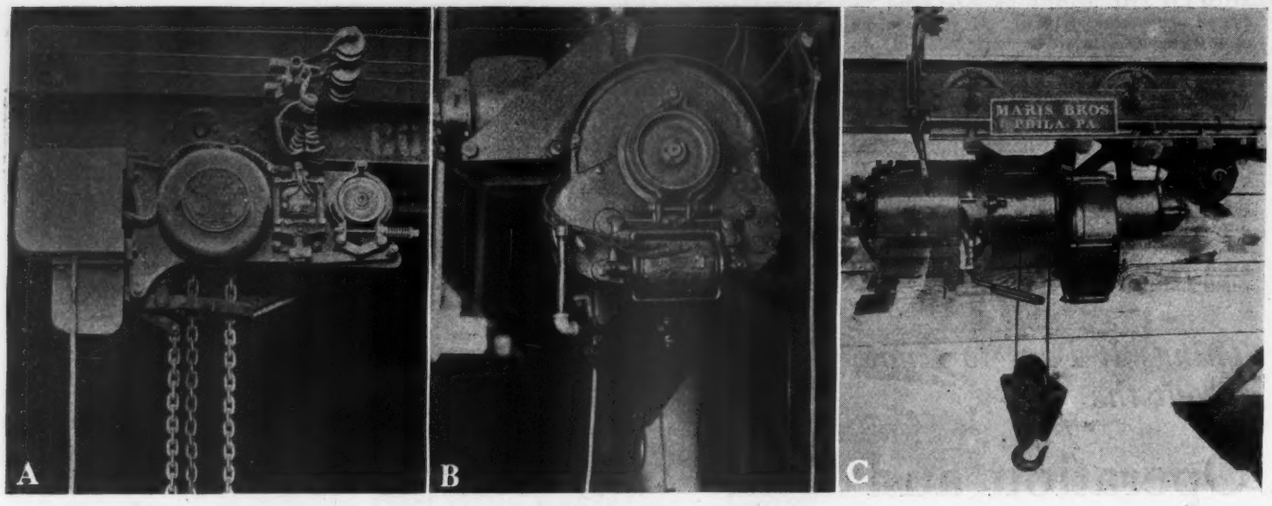
When the power supply is direct current, the series-wound motor is universally used for small hoists. When alternating current is available, the squirrel-cage motor is almost always used; the slip-ring motor is used only when accurate control of speed is required. Slip-ring motors are more expensive, require more maintenance, and necessitate the use of a more expensive control; for these reasons their use is avoided, whenever possible.

For controlling the starting, stopping and speed of the motor, there are two general types of control: namely, manual control and magnetic control.

A hoist with manual control is shown in illustration *G* on page 529 and in illustration *C* on page 554. The manual control is operated by pulling the proper cord for hoisting or lowering, the magnetic control by pushing the proper button. Sometimes the push buttons are located at the end of a conduit which forms a convenient means for pushing the hoist along its track, as is shown in the illustration at the bottom of page 528. More frequently, the push buttons are mounted in a pendant station suspended from armored cable. It is essential that firm and reliable anchorage be provided between the armor of the cable and the pendant station, for if this ground is broken there is always danger of shock to the operator. For the same reason, the armor should be firmly anchored to the metal frame of the hoist.

Advantages of Magnetic Control for Small Hoists

The principal advantages of the magnetic control over the manual control are: (1) ease of operation, (2) accuracy of "spotting" the load, and (3) reduced maintenance. When the manual control is used, the proper contacts are closed by pulling the cord, and a spring opens the contacts when the cord is released. A considerable motion of the cord is required, and the parts have some inertia; so there is a small time inter-



These small hoists are provided with brakes and limit stops.

In illustration *A* is shown a close-up view of the hoist illustrated on page 527. The solenoid-operated brake at the extreme right functions on the armature shaft. The hoisting chain passes through a hole in the operating lever of the limit stop. In illustration *B* is shown a small hoist having a motor-operated trolley. Manual control is used for both hoist and trolley. The hoist has a solenoid brake somewhat similar to the one shown in illustration *A*. At *C* is shown another manually-controlled hoist. The operating lever of the limit switch projects directly above the sheave of the hook block.

val between the pull or the release of the cord and the corresponding action of the hoist. While a skilled operator can make some allowance for this, no such allowance is required when the magnetic control is used, the action of the hoist being practically instantaneous upon depressing or releasing the push button. With magnetic control, it is easily possible to "spot" the load, hoisting or lowering, at full speed, within half an inch of the desired point.

If starting and stopping of the hoist are very frequent, magnetic control should be selected regardless of other conditions, because of reduced maintenance expense. A one-minute cycle may be considered as being severe enough to justify the added expense of magnetic control, even though manual control is otherwise satisfactory.

The prospective purchaser of an electric hoist should also consider whether delays for repairs will involve large expense due to loss of production. While a well-designed control of either the manual or magnetic type will probably be the cause of fewer delays than are caused by failure of other parts of the hoist, the magnetic control will in general require less frequent adjustment than the manual control, and may for this reason, even in light service, be desirable, if it is a part of a high-production unit.

Manual Control Is Required by Some Applications

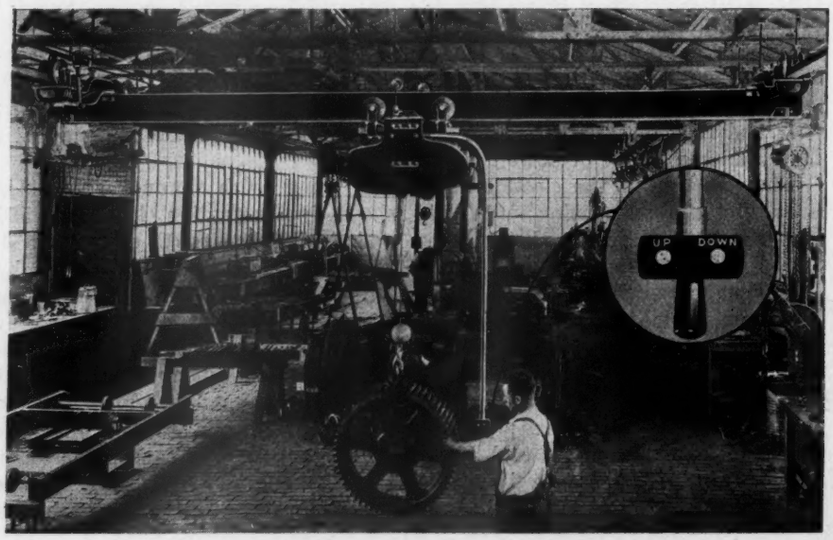
It must not be concluded, however, that the manual control is generally an inferior type. A well-designed, manual controller is a simple and reliable mechanism, and large numbers of them are giving highly satisfactory service. The magnetic type of control requires, in general, a higher grade of maintenance, and where a plant electrician is not available, the simpler manual controller may be preferred. There are also, as will be noted later, certain control features which cannot readily be secured in magnetic control.

For example, in addition to accuracy of "spotting" referred to above, accurate control of hoisting or lowering speed is sometimes required. In foundry work in particular, this is an essential feature. If, for instance, the full-load speed of the hook is 30 ft. per min., for foundry service, it will probably be necessary to provide for an empty-hook speed of 10 ft. per min. This should be obtainable both in hoisting and lowering, in order to pick up and deposit flasks gently. It is usual to provide three or four speeds when speed control is required, so that the operator can select the speed most suitable to the load and conditions of operation. In general, manual control is preferable to magnetic control for this service, because of the cost, size, and complication of magnetic control with the multi-speed feature. Multi-speed hoists are rarely furnished where alternating-current power is used.

Manual controllers are of two general types—drum type and faceplate type; the faceplate type was the earlier design, but the drum type is now used almost universally. A typ-

The push button operating the magnet control for this small hoist is mounted on a rigid arm.

This construction is of advantage as the arm forms a convenient handle for pushing or pulling the trolley along its track or runway.



ical drum-type controller is shown in *E'* of the illustration on this page. It consists of a cylinder carrying copper segments which, when the cord is pulled, make contact with fingers to complete the circuit between power supply and motor.

Factors Governing Selection of Small-Hoist Control

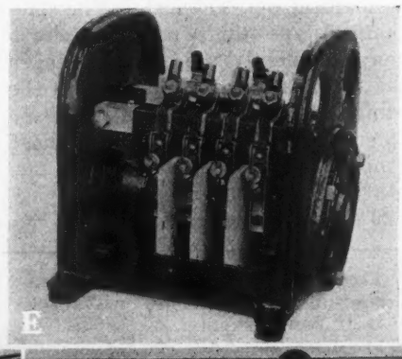
The points to be noted in selecting a drum-type, hoist controller are: (1) Clearance between live parts and ground and between parts of opposite polarity should be ample. Operation of the drum will deposit copper dust on exposed surfaces, and unless the clearances are ample the intervals between cleaning will be unduly short. (2) Barriers should be provided to prevent flashing. (3) Fingers should be readily adjustable and self-aligning with the segments. Finger pressure springs should not carry current. (4) The return spring should return drum cylinder, handle, and cords to neutral position quickly upon release of cord. (5) The centering device should stop the drum positively in neutral when drum is released from running position. (6) The handle should be sufficiently long to operate without excessive pull on the cord. (7) Wearing parts (segments and fingers) should be easily accessible for repair. (8) Drum should be easy to wire. (9) The controller should be enclosed by a dust-proof cover.

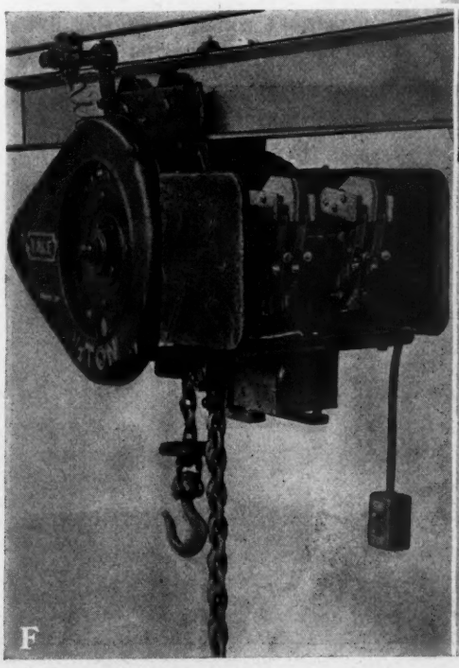
The magnetic controller for small hoists consists of two contactors, one for each direction, mechanically interlocked so that both cannot be closed simultaneously, and a two-button control station. Details of a magnetic controller can be seen in illustration *F* on this page. The points to be noted in selecting a magnetic hoist control are: (1) Magnetic blow-out should be furnished on contactors for direct-current service. (2) Ample clearances should be allowed. (3) Contact surfaces should be self-aligning. (4) Coils should be filled with moisture-proof impregnating compound after winding. (5) Controller should be easy to wire. (6) Controller should be enclosed by a dust-proof cover. (7) Push-button contacts and operating buttons should be "husky." (8) A guard should be provided around the buttons to prevent breakage. (9) The case containing the push buttons should be tapped for conduit about 1½ in. in diameter, or should be supported from armored cable.

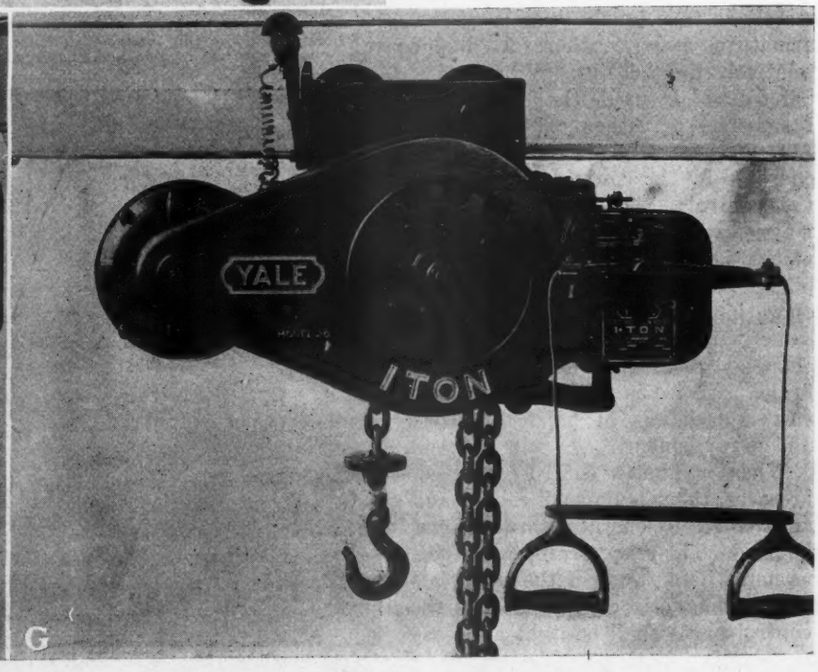
Operation of Brakes Used on Small Hoists

The majority of electric hoists have a friction brake, commonly called the load brake, to control the lowering speed. When worm reduction is used between the motor and winding drum, the worm is made non-overhauling and will hold the load unless power is applied to the motor. When a load is being lowered, the thrust of the worm against a friction bearing is balanced by the thrust due to rotation of the worm by the motor. The lowering speed is thus determined by the speed-torque characteristics of the motor, and will vary inversely with the weight on the hook. If spur-gear or chain reduction is used between motor and winding drum, the lowering speed is governed by friction discs which engage when the load is being lowered and are separated when hoisting, as shown at (*1*) in illustration *B* on page 554.

Instead of a mechanical brake to limit the lowering speed, an electrical (dynamic) brake is sometimes used where direct current is the source of power. The control is so arranged that, when it is moved to the lowering position, the motor is converted into a generator which feeds current







Three views showing manual and magnetic controls as used on small hoists.

In illustration *F* is shown a hoist having magnetic control. As can be seen, the control consists of two double-pole contactors which are controlled from the push-button switch. At *G* is illustrated a manually-controlled hoist. Illustration *E* shows the details of the manual controller. This type of manual control is known as a drum reverse switch. Four fingers or contacts engage with segments on the drum which is operated by means of the two ropes shown in illustration *G*.

Control Accessories Used on Small Hoists

Control	Lowering Brake	Motor Brake	Limit Stop
Manual	Mechanical (a. c. or d. c.)	Mechanical	Mechanical (positive or clutch type)
Manual	Electrical (dynamic-d. c. only)	Electrical	Electrical (main circuit)
Magnetic	Mechanical		
Magnetic	Electrical	Electrical	Electrical (main circuit or pilot circuit)

into a properly-designed resistor. Briefly, the energy of the falling load on the hook is converted into heat in the resistor, and the speed of lowering thereby governed. The characteristics of the dynamic brake are such that the speed of lowering varies directly with the weight on the hook; that is, a heavy load is lowered a little faster than a light load. Several control points can be furnished, so that the operator can adjust the lowering speed to suit conditions. For hoists of the type discussed in this article, speed adjustment is very rarely necessary. Dynamic braking cannot be obtained with alternating-current motors.

Since the motor drives the load during lowering, a brake is usually applied to the motor shaft when power is cut off to absorb the inertia of the armature, which otherwise would continue to rotate for a short time and allow the hook to drift. The brake usually is of the shoe type, applied by a spring. It is not required to stop the load, but merely to take up the inertia of the armature, and can therefore be of relatively light design. When manual control is used, the brake may be opened in either of two ways: (1) mechanically, by some device operated by the cords which actuate the control; (2) electrically, by a magnet whose winding is energized at the same time that power is applied to the motor. The method of operation and the results are the same with either electrical or mechanical operation of the motor brake. Choice is made according to cost and details of hoist structure and arrangement.

When magnetic control is used, however, there is no such choice, and an electrically-operated brake must be used. The reason for this is that, as noted before, one of the essentials of the magnetic control is that the control parts shall be light and easy to manipulate. This means that the release of the brake, which requires considerable effort, must be affected electrically rather than manually. A solenoid-operated brake is shown in *B* of the illustration on page 528.

Small Hoists Use Several Types of Limit Stops

Most electric hoists have a device to prevent overtravel of the hook in the up direction, and sometimes means to limit the travel in the down direction. When manual control is used, the limit stop may be either mechanical or electrical. The mechanical-type limit stop, which is more frequently used, usually takes the form of a bar which pushes the controller to the neutral position when the hook reaches the danger zone, simultaneously setting the motor brake. Illustration *G* on page 529 shows a hoist control with a mechanical-type limit stop. In another type of mechanical limit stop the controller is of the drum type and is designed with clutch between the contact-making drum and the operating handle. When the hook reaches the danger zone, the clutch is released and the return spring snaps the control drum to the open-circuit position. The clutch is re-engaged by pulling on the reverse control cord. The advantage of this type of overtravel limit is that the contacts are opened and closed very quickly, thus reducing the burning of the contacts and allowing close adjustment of the stop.

The electrical type of limit stop may also be used with manual control. This type of stop consists of a switch in series with the motor, the switch being opened when the hook reaches the limit. The switch must open one line of a direct-current circuit, and two lines of an alternating-current circuit. The lines which are opened in the electrical-type limit stop must be bypassed when the controller makes the circuit for the opposite direction.

The choice of mechanical-type or electrical-type limit stop, like the choice of manually- or electrically-operated motor brake, depends on the relative cost as affected by the details and arrangement of the parts of the hoist.

When magnetic control is used, the electrical type of limit switch is required. This switch may open the motor circuit, in which case the requirements are the same as for the electrical type of stop when used with manual control; or the limit switch may (*Continued on page 554*)

These hoists use an extension cord instead of trolley wires for their power supply.

The extension cord is plugged into the power supply wherever it is desired to hoist or lower the load. This does away with the use of two pulley wires.

Some Symptoms of

Lightning Arrester Troubles—

Their Diagnosis and Remedies

Compiled by H. E. STAFFORD,

Electrical Engineer,
Provincial Paper Mills,
Port Arthur, Ont., Can.

SYMPTOM	TROUBLE	CAUSE	REMEDY
1. Gaps continue to arc when set in operating position.	Abnormal arcing.	1. Too small gap setting. 2. Gap electrodes out of shape. 3. Voltage greater than normal due to crossing with higher voltage lines. 4. Generator voltage too high. 5. Films not properly formed.	1. Increase gap setting. 2. Straighten horns to proper alignment. 3. Repair lines if crossed. 4. Adjust generator voltage. 5. Examine cells and renew defective ones.
2. Arc at horns or sphere gaps too intense.	Excessive charging current.	1. Improper charging. 2. Arcing ground on line at time of charging. 3. Electrolyte deteriorated.	1. Use proper method of charging in regard to time, holding the gaps on short-circuit not longer than 5 to 10 seconds. 2. Locate and repair causes of ground or abnormal arcing. 3. Renew electrolyte in cells.
3. A rumbling noise issues from tanks.	Arcing in oil.	1. One or more empty cells. 2. One or more punctured cones. 3. Electrolyte in contact with wooden rods or insulating separators.	1. Fill cells with electrolyte. 2. Remove and replace with new cones, putting new ones at top of the stack. 3. Wash all traces of electrolyte from rods and spacers and see that same does not come in contact when refilling and assembling.
4. Oil is thrown from tanks.	Arcing in oil.	Same as above 3 causes. 4. Electrolyte becomes heated due to prolonged short-circuit of horns or sphere gaps.	Same as above 3 remedies. 4. When this happens, the electrolyte becomes boiled down and it is usually necessary to take down the entire stack, clean each cone, renew any cones which may be punctured or on which the film is gone and refill and charge the arrester.*
5. A sizzling or crackling noise issues from the tanks.	Due to scintillation.	Voltage concentration on any spots in the cell not properly filmed.	This does no real harm unless it is aggravated and becomes the same as symptom 4. No notice need be taken of this symptom.
6. A sizzling or crackling noise issues from some part of the arrester outside the tanks.	Leakage current.	1. Dust or moisture on insulators and resistance units. 2. Cracked or chipped insulators.	1. Clean insulators, frame work and resistance units and remove all traces of moisture. 2. Renew defective insulators.
7. Arcing at points of arrester mechanism other than horns or spheres.	1. Loose or broken connections. 2. Broken ground connection.	1. Carelessness in assembling or due to prolonged arc due to short-circuiting of horns. 2. Corrosion or damage.	1. Repair loose connections and polish all contacts with sand paper and shellac all current carrying parts. 2. Repair break, first cutting the arrester from the line. The arrester is useless and also a hazard when the ground connection is broken, and therefore all ground connections should be periodically inspected and tested. One ground should never be depended upon, two or three being necessary.

* In taking down the stacks of aluminum cell arresters, each cone should be lifted from the wooden supports separately, handling them by the rim only. The contents is emptied out and the cell washed with gasoline or ivory soap, the latter preferred, and thoroughly dried with fine cheese cloth. As each cell or cone is finished it is inverted, with the insulating spacers, which should also be washed and dried, between the cones. In this manner, the cones will occupy the same position when again assembled. The cells when assembled should be immediately filled with electrolyte, to the height called for by the manufacturers, and charged and immediately put in service.

Handy Tables For Use in

Laying Out Wave Windings for A. C. Motors

Complete With Instructions and Worked-Out Examples Showing How the Tables Are Used Together With Details of the Way They Are Derived

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THIS IS the third of a series of articles on alternating-current, wave windings. The first two articles, which were published in the September and October issues, explained how to lay out and construct wave windings for three-phase, two-phase, and single-phase stators having two-layer windings. This article gives short-cut methods and tabulations of data for use in laying out this type of winding. A succeeding article will give similar tabulations for use on rotor windings and will also discuss how to lay out wave windings for machines in which the number of slots is not a multiple of the number of poles.

PREVIOUS articles in the September and October issues explained how to lay out and construct two-layer wave windings for three-phase, two-phase and single-phase stators. We will now take up some of the short-cut methods that may be used to accomplish the same ends with a great deal less time and effort.

After a winder thoroughly understands the principles of wave windings, he will not need a diagram to make the connections. He will be able to figure out the slot in which each lead, short pitch, and reversing jumper will be located, jot down the slot numbers on a sheet of paper and connect up his winding from this data. He will have to use a standard method of connection for all makes of machines, but this will not cause any trouble except where the leads outside the machine are too large to interchange or in the case of machines such as turbo-generators, in which the line leads must have the same relation before and after rewinding. These are in the minority however, and for the general run of cases a standard connection method will prove satisfactory. Consequently, the only things that can affect the winding are: (1) Changing the manner of picking up the leads. (2) Using a left-hand in place of a right-hand winding, or *vice versa*. (3) Connecting the line leads to top conductors in place of the bottom conductors, or *vice versa*. The latter will reverse the direction of rotation in a motor or will change the polarity of the leads in a generator. Interchanging any two leads outside the machine will correct this defect.

In the majority of cases any small changes, such as noted in the preceding paragraph, can be corrected. Therefore a set of tables has been compiled that gives the winding data for a number of standard makes of machines. As each manufacturer has his own method of connecting up a wave winding, one standard method was adopted and used. This standard method will be found satisfactory, unless some very special feature is found in the machine to be rewound.

Tables I to V inclusive given on the following pages are for two-phase, motor windings. Tables VI to X inclusive are for three-phase, motor windings. Table I gives the number of coils from 16 to 216 that will form a balanced two-phase, four-pole winding. The first column gives the number of coils in the winding, the second column gives the coils per section, the third column gives the coils per group, which is also the number of times the winding will be encircled and is equal to the number of series per section, and the fourth column indicates the full front pitch. The fifth, sixth, seventh and eighth columns give the slot numbers in which fall the conductors connecting to the A_1, B_1, A_2, and B_2 leads. The ninth column gives the location of the conductors to which the reversing jumpers are connected. The tenth column gives the location of the conductors which are connected to form the short-pitch connections. The last or eleventh column gives the total number of short jumper clips in the entire winding.

In laying out a winding, the slots should be numbered in a clockwise direction around the stator, if the coils are to be wound in for a left-hand winding. If a right-hand winding is to be laid out, the slots should be numbered around the stator in a counter-clockwise direction. In all of the tables given on the following pages, the A_1 lead is started in slot *1*. Usually the line leads, A_1, A_2, B_1 and B_2 are connected to top conductors. In this case, the reversing jumpers will be connected to bottom conductors. Hence, in the tables, the fifth, sixth, seventh, and eighth columns give the slots which hold the top conductors that the line leads are to be connected to. The ninth column gives the slots holding the bottom conductors which the reversing jumpers are to be connected to. In Table I, for the sixteen-coil winding the bottom conductors of slots *8* and *12* are to be connected together to form one reversing jumper while the bottom conductors in slots *2* and *6* are to be connected together to form the other reversing jumper.

In the short-pitch column, the first figure gives the number of the slot in which a bottom conductor is to be used and the second figure gives the number of the slot in which a top conductor is to be used. These two conductors are connected together for the short-pitch connection. As an example, take the sixteen-coil winding of Table I. In this winding the first short-pitch connection will occur between the bottom conductor in slot *13* and the top conductor in slot *16*; the second short-pitch connection occurs between the bottom conductor in slot *9* and the top conductor in slot *12*, and so on for the other two short-pitch connections. In windings where there are more than two

Table I—Four-Pole, Two-Phase Windings

The following tables give the winding data required for laying out wave windings. If the number of poles, number of phases and number of coils are known, reference to the proper table will give the coils per section, coils per group, winding pitch, and the location of the line leads, star leads, reversing jumpers, and short pitch connections. With this data the winder can connect up the winding without the use of a diagram or other information.

For a left-hand winding number slots in a clockwise direction.

For a right-hand winding number slots in a counter-clockwise direction.

In the last column to the right are given the number of short jumper (S. J.) clips.

No. of Coils	Coils Per Section	Coils Per Group	Pitch	Line Leads *Top Conductors* A1	B1	A2	B2	Reversing Jumpers *Bottom to Bottom*	Short-Pitch Connections *Connected Bottom to Top*	No. S. J. Clips
16	4	2	1 & 5	1	11	13	7	(8- 12) (2- 6)	(13-16) (9-12) (7-10) (3-6)	4
24	6	3	1 & 7	1	16	19	10	(11- 17) (2- 8)	(18- 23, 19- 24) (12- 17, 13- 18) (9- 14, 10- 15) (3- 8, 4-9)	8
32	8	4	1 & 9	1	21	25	13	(14- 22) (2-10)	(23- 30, 25- 32) (15- 22, 17- 24) (11- 18, 13- 20) (3-10, 5-12)	12
40	10	5	1 & 11	1	26	31	16	(17- 27) (2-12)	(28- 37, 31- 40) (18- 27, 21- 30) (13- 22, 16- 25) (3-12, 6-15)	16
48	12	6	1 & 13	1	31	37	19	(20- 32) (2-14)	(33- 44, 37- 48) (21- 32, 25- 36) (15- 26, 19- 30) (3-14, 7-18)	20
56	14	7	1 & 15	1	36	43	22	(23- 37) (2-16)	(38- 51, 43- 56) (24- 37, 29- 42) (17- 30, 22- 35) (3-16, 8-21)	24
64	16	8	1 & 17	1	41	49	25	(26- 42) (2-18)	(43- 58, 49- 64) (27- 42, 33- 48) (19- 34, 25- 40) (3-18, 9-24)	28
72	18	9	1 & 19	1	46	55	28	(29- 47) (2-20)	(48- 65, 55- 72) (30- 47, 37- 54) (21- 38, 28- 45) (3-20, 10-27)	32
80	20	10	1 & 21	1	51	61	31	(32- 52) (2-22)	(53- 72, 61- 80) (33- 52, 41- 60) (23- 42, 31- 50) (3-22, 11-30)	36
88	22	11	1 & 23	1	56	67	34	(35- 57) (2-24)	(58- 79, 67- 88) (36- 57, 45- 66) (25- 46, 34- 55) (3-24, 12-33)	40
96	24	12	1 & 25	1	61	73	37	(38- 62) (2-26)	(63- 86, 73- 96) (39- 62, 49- 72) (27- 50, 37- 60) (3-26, 13-36)	44
104	26	13	1 & 27	1	66	79	40	(41- 67) (2-28)	(68- 93, 79-104) (42- 67, 53- 78) (29- 54, 40- 65) (3-28, 14-39)	48
112	28	14	1 & 29	1	71	85	43	(44- 72) (2-30)	(73-100, 85-112) (45- 72, 57- 84) (31- 58, 43- 70) (3-30, 15-42)	52
120	30	15	1 & 31	1	76	91	46	(47- 77) (2-32)	(78-107, 91-120) (48- 77, 61- 90) (33- 62, 46- 75) (3-32, 16-45)	56
128	32	16	1 & 33	1	81	97	49	(50- 82) (2-34)	(83-114, 97-128) (51- 82, 65- 96) (35- 66, 49- 80) (3-34, 17-48)	60
136	34	17	1 & 35	1	86	103	52	(53- 87) (2-36)	(88-121, 103-136) (54- 87, 69-102) (37- 70, 52- 85) (3-36, 18-51)	64
144	36	18	1 & 37	1	91	109	55	(56- 92) (2-38)	(93-128, 109-144) (57- 92, 73-108) (39- 74, 55- 90) (3-38, 19-54)	68
152	38	19	1 & 39	1	96	115	58	(59- 97) (2-40)	(98-135, 115-152) (60- 97, 77-114) (41- 78, 58- 95) (3-40, 20-57)	72
160	40	20	1 & 41	1	101	121	61	(62-102) (2-42)	(103-142, 121-160) (63-102, 81-120) (43- 82, 61-100) (3-42, 21-60)	76
168	42	21	1 & 43	1	106	127	64	(65-107) (2-44)	(108-149, 127-168) (66-107, 85-126) (45- 86, 64-105) (3-44, 22-63)	80
176	44	22	1 & 45	1	111	133	67	(68-112) (2-46)	(113-156, 133-176) (69-112, 89-132) (47- 90, 67-110) (3-46, 23-66)	84
184	46	23	1 & 47	1	116	139	70	(71-117) (2-48)	(118-163, 139-184) (72-117, 93-138) (49- 94, 70-115) (3-48, 24-69)	88
192	48	24	1 & 49	1	121	145	73	(74-122) (2-50)	(123-170, 145-192) (75-122, 97-144) (51- 98, 73-120) (3-50, 25-72)	92
200	50	25	1 & 51	1	126	151	76	(77-127) (2-52)	(128-177, 151-200) (78-127, 101-150) (53-102, 76-125) (3-52, 26-75)	96
208	52	26	1 & 53	1	131	157	79	(80-132) (2-54)	(133-184, 157-208) (81-132, 105-156) (55-106, 79-130) (3-54, 27-78)	100
216	54	27	1 & 55	1	136	163	82	(83-137) (2-56)	(138-191, 163-216) (84-137, 109-162) (57-110, 81-135) (3-56 28-81)	104

Table II—Six-Pole, Two-Phase Windings

See heading of Table I for instructions on numbering slots.

No. of Coils	Coils Per Section	Coils Per Group	Pitch	Line Leads *Top Conductors* A1	B1	A2	B2	Reversing Jumpers *Bottom to Bottom*	Short-Pitch Connections *Connected Bottom to Top*	No. S. J. Clips
24	6	2	1 & 5	1	11	21	7	(16- 20) (2- 6)	(21-24) (17-20) (7-10) (3-6)	4
36	9	3	1 & 7	1	16	31	10	(23- 29) (2- 8)	(30- 35, 31- 36) (24- 29, 25- 30) (9-14, 10-15) (3- 8, 4- 9)	8
48	12	4	1 & 9	1	21	41	13	(30- 38) (2-10)	(39- 46, 41- 48) (31- 38, 33- 40) (11-18, 13-20) (3-10, 5-12)	12
60	15	5	1 & 11	1	26	51	16	(37- 47) (2-12)	(48- 57, 51- 60) (38- 47, 41- 50) (13-22, 16-25) (3-12, 6-15)	16
72	18	6	1 & 13	1	31	61	19	(44- 56) (2-14)	(57- 68, 61- 72) (45- 56, 49- 60) (15-26, 19-30) (3-14, 7-18)	20
84	21	7	1 & 15	1	36	71	22	(51- 65) (2-16)	(66- 79, 71- 84) (52- 65, 57- 70) (17-30, 22-35) (3-16, 8-21)	24
96	24	8	1 & 17	1	41	81	25	(58- 74) (2-18)	(75- 90, 81- 96) (59- 74, 65- 80) (19-34, 25-40) (3-18, 9-24)	28
108	27	9	1 & 19	1	46	91	28	(65- 83) (2-20)	(84-101, 91-108) (66- 83, 73- 90) (21-38, 28-45) (3-20, 10-27)	32
120	30	10	1 & 21	1	51	101	31	(72- 92) (2-22)	(93-112, 101-120) (73- 92, 81-100) (23-42, 31-50) (3-22, 11-30)	36
132	33	11	1 & 23	1	56	111	34	(79-111) (2-24)	(102-123, 111-132) (80-101, 89-110) (25-46, 34-55) (3-24, 12-33)	40
144	36	12	1 & 25	1	61	121	37	(86-120) (2-26)	(111-134, 121-144) (87-110, 97-120) (27-50, 37-60) (3-26, 13-36)	44
156	39	13	1 & 27	1	66	131	40	(93-129) (2-28)	(120-145, 131-156) (94-119, 105-130) (29-54, 40-65) (3-28, 14-39)	48
168	42	14	1 & 29	1	71	141	43	(100-138) (2-30)	(129-156, 141-168) (101-128, 113-140) (31-58, 43-70) (3-30, 15-42)	52
180	45	15	1 & 31	1	76	151	46	(107-147) (2-32)	(138-167, 151-180) (108-137, 121-150) (33-63, 46-75) (3-32, 16-45)	56
192	48	16	1 & 33	1	81	161	49	(114-156) (2-34)	(147-178, 161-192) (115-146, 129-160) (35-66, 49-80) (3-34, 17-48)	60
204	51	17	1 & 35	1	86	171	52	(121-165) (2-36)	(156-189, 171-204) (122-155, 137-170) (37-70, 52-85) (3-36, 18-51)	64
216	54	18	1 & 37	1	91	181	55	(128-174) (2-38)	(165-200, 181-216) (129-164, 145-180) (39-74, 55-90) (3-38, 19-54)	68

Table III—Eight-Pole, Two-Phase Windings

See heading of Table I for instructions on numbering slots.

No. of Coils	Coils Per Section	Coils Per Group	Pitch	Line Leads *Top Conductors* A1	B1	A2	B2	Reversing Jumpers *Bottom to Bottom*	Short-Pitch Connections *Connected Bottom to Top*	No. S. J. Clips
32	8	2	1 & 5	1	11	29	7	(24- 28) (2- 6)	(29-32) (25-28) (7-10) (3-6)	4
48	12	3	1 & 7	1	16	43	10	(35- 41) (2- 8)	(42- 47, 43- 48) (36- 41, 37- 42) (9-14, 10-15) (3- 8, 4- 9)	8
64	16	4	1 & 9	1	21	57	13	(46- 54) (2-10)	(55- 62, 57- 64) (47- 54, 49- 56) (11-18, 13-20) (3-10, 5-12)	12
80	20	5	1 & 11	1	26	71	16	(57- 67) (2-12)	(68- 77, 71- 80) (58- 67, 61- 70) (13-22, 16-25) (3-12, 6-15)	16
96	24	6	1 & 13	1	31	85	19	(68- 80) (2-14)	(81- 92, 85- 96) (69- 80, 73- 84) (15-26, 19-30) (3-14, 7-18)	20
112	28	7	1 & 15	1	36	99	22	(79- 93) (2-16)	(94-107, 99-112) (80- 93, 85- 98) (17-30, 22-35) (3-16, 8-21)	24
128	32	8	1 & 17	1	41	113	25	(90-106) (2-18)	(107-122, 113-128) (91-106, 97-112) (19-34, 25-40) (3-18, 9-24)	28
144	36	9	1 & 19	1	46	127	28	(101-119) (2-20)	(120-137, 127-144) (102-119, 109-126) (21-38, 28-45) (3-20, 10-27)	32
160	40	10	1 & 21	1	51	141	31	(112-132) (2-22)	(133-152, 141-160) (113-132, 121-140) (23-42, 31-50) (3-22, 11-30)	36
176	44	11	1 & 23	1	56	155	34	(123-145) (2-24)	(146-167, 155-176) (124-145, 133-154) (25-46, 34-55) (3-24, 12-33)	40
192	48	12	1 & 25	1	61	169	37	(134-158) (2-26)	(159-182, 169-192) (135-158, 145-168) (27-50, 37-60) (3-26, 13-36)	44
208	52	13	1 & 27	1	66	183	40	(145-171) (2-28)	(172-197, 183-208) (146-171, 167-182) (29-54, 40-65) (3-28, 14-39)	48
224	56	14	1 & 29	1	71	197	43	(156-184) (2-30)	(185-212, 197-224) (157,184, 179-196) (31-58, 43-70) (3-30, 15-42)	52

short-pitch connections, the slot numbers of the first and last short-pitch connections are given. For the thirty-two-coil winding in the third line of Table I, there appears in the tenth or short-pitch column, a group of four figures in brackets, the first group being (*23-30, 25-32*). This means that the bottom conductors in slots *23*, *24* and *25* are to be connected to the top conductors in slots *30*, *31* and *32* respectively; that is, the bottom conductor in slot *23* is to be connected to the top conductor in slot *30*, the bottom conductor in slot *24* is to be connected to the top conductor in slot *31*, and the bottom conductor in slot *25* is to be connected to the top conductor in slot *32*. This method saves time and space in compiling the tables.

Tables VI to X are for three-phase windings, having from four to twelve poles and connected series star or series delta. In these tables, the line leads and the star connections are the top conductors in the slots indicated in the fifth, sixth, seventh, eighth, ninth, and tenth columns. The line leads are designated by *A*, *B* and *C*; the star connections are indicated by A_1, B_1 and C_1. The tables give the arrangements direct for a series-star connection; that is, for the twenty-four-coil winding in Table VI, the line leads connect to the top conductors in slots *1*, *9* and *17* respectively, and the star connection is formed by joining together the top conductors in slots *19*, *3* and *11*. If a series-delta connection for the same winding is desired, the connection scheme is given at the top of Table VI. The leads *A* and B_1 connect to one line, the leads *B* and C_1 connect to the next line and the leads *C* and A_1 connect to the third line. That is, the top conductors in slots *1* and *3* connect to one line, the top conductors of slots *9* and *11* connect to the second line, and the top conductors in slots *17* and *19* connect to the third line.

The winding layout given in the table will bring the line leads close together. A method of figuring the layout for other spacings will be given later. The precautions necessary when laying out the winding in the motor are: first, that the slots be numbered in a clockwise direction for a left-hand winding and in a counter-clockwise direction for a right-hand winding; and second, that the winder face the connection end of the stator when laying out the slot numbers and when determining whether the winding is to be right hand or left hand.

These tables apply to right- and left-hand windings having the leads connected to top conductors. The tables can also be used when it is desired to use the bottom conductors for leads. For a left-hand winding in which bottom conductors are connected to the line leads, the slots should be numbered in a counter-clockwise direction. Then instead of taking the top conductors in the slots indicated in the table for the line and star leads, use the bottom conductors in the same slots. The reversing jumpers will be connected to top conductors instead of bottom conductors and will use the same slots as the table shows. For the short-pitch connections, it is only necessary to change the tables to read top to bottom, instead of bottom to top. For example, in the first line (twenty-four-coil winding) of Table VI, the first short-pitch connection will occur between the top conductor of slot *19* and the bottom conductor of slot *24* instead of the bottom conductor of slot *19* and the top conductor of slot *24*, as the table reads.

If it is desired to use bottom conductors for line leads and have a right-hand winding, the slots should be numbered in a clockwise direction. The line leads will be connected to bottom conductors, the reversing jumpers will be connected to top conductors and the short-pitch connections will be the same as has been

Table IV—Ten-Pole, Two-Phase Windings

See heading of Table I for instructions on numbering slots.

No. of Coils	Coils Per Section	Coils Per Group	Pitch	Line Leads Top Conductors A_1	B_1	A_2	B_2	Reversing Jumpers Bottom to Bottom	Short-Pitch Connections Connected Bottom to Top	No. S. J. Clips
20	5	1	1 & 3	1	6	19	4	(17- 19) (2- 4)	None	0
40	10	2	1 & 5	1	11	37	7	(32- 36) (2- 6)	(37-40) (33-36) (7-10) (3-6)	4
60	15	3	1 & 7	1	16	55	10	(47- 53) (2- 8)	(54- 59, 55- 60) (48- 53, 49- 54) (9-14, 10-15) (3- 8, 4- 9)	8
80	20	4	1 & 9	1	21	73	13	(62- 70) (2-10)	(71- 78, 73- 80) (63- 70, 65- 72) (11-18, 13-20) (3-10, 5-12)	12
100	25	5	1 & 11	1	26	91	16	(77- 87) (2-12)	(88- 97, 91-100) (78- 87, 81- 90) (13-22, 16-25) (3-12, 6-15)	16
120	30	6	1 & 13	1	31	109	19	(92-104) (2-14)	(105-116, 109-120) (93-104, 97-108) (15-26, 19-30) (3-14, 7-18)	20
140	35	7	1 & 15	1	36	127	22	(107-121) (2-16)	(122-135, 127-140) (108-121, 113-126) (17-30, 22-35) (3-16, 8-21)	24
160	40	8	1 & 17	1	41	145	25	(122-138) (2-18)	(139-154, 145-160) (123-138, 129-144) (19-34, 25-40) (3-18, 9-24)	28
180	45	9	1 & 19	1	46	163	28	(137-155) (2-20)	(156-173, 163-180) (138-155, 145-162) (21-38, 28-45) (3-20, 10-27)	32
200	50	10	1 & 21	1	51	181	31	(152-172) (2-22)	(173-192, 181-200) (153-172, 161-180) (23-42, 31-50) (3-22, 11-30)	36
220	55	11	1 & 23	1	56	199	34	(167-189) (2-24)	(190-211, 199-220) (168-189, 177-198) (25-46, 34-55) (3-24, 12-33)	40

Table V—Twelve-Pole, Two-Phase Windings

See heading of Table I for instructions on numbering slots.

No. of Coils	Coils Per Section	Coils Per Group	Pitch	Line Leads Top Conductors A_1	B_1	A_2	B_2	Reversing Jumpers Bottom to Bottom	Short-Pitch Connections Connected Bottom to Top	No. S. J. Clips
24	6	1	1 & 3	1	6	23	4	(21- 23) (2- 4)	None	0
48	12	2	1 & 5	1	11	45	7	(40- 44) (2- 6)	(45-48) (41-44) (7-10) (3-6)	4
72	18	3	1 & 7	1	16	67	10	(59- 65) (2- 8)	(66- 71, 67- 72) (60- 65, 61- 66) (9-14, 10-15) (3- 8, 4- 9)	8
96	24	4	1 & 9	1	21	89	13	(78- 86) (2-10)	(87- 94, 89- 96) (79- 86, 81- 88) (11-18, 13-20) (3-10, 5-12)	12
120	30	5	1 & 11	1	26	111	16	(97-107) (2-12)	(108-117, 111-120) (98-107, 101-110) (13-22, 16-25) (3-12, 6-15)	16
144	36	6	1 & 13	1	31	133	19	(116-128) (2-14)	(129-140, 133-144) (117-128, 121-132) (15-26, 19-30) (3-14, 7-18)	20
168	42	7	1 & 15	1	36	155	22	(135-149) (2-16)	(150-163, 155-168) (136-149, 141-154) (17-30, 22-35) (3-16, 8-21)	24
192	48	8	1 & 17	1	41	177	25	(154-170) (2-18)	(171-186, 177-192) (155-170, 161-176) (19-34, 25-40) (3-18, 9-24)	28
216	54	9	1 & 19	1	46	199	28	(173-191) (2-20)	(192-209, 199-216) (174-191, 181-198) (21-38, 28-45) (3-20, 10-27)	32

outlined in the preceding paragraph.

The way to apply the data given in the tables direct to the winding, without the use of a diagram, is as follows:

(1) Locate the slot that is on the center line of the terminal block. Call this the B-phase, line-lead slot.

(2) The tables will give the number of the B-phase, line-lead slot and using this as a starting point, all of the other slots can be numbered.

(3) The coils should now be put in the stator in the proper group formation. The first and last coils of each group are phase coils and should have phase insulation. The number of coils in a group is given in the third column of the table; hence the location of the phase coils can be readily determined.

(4) Locate the conductors to which the line leads and star leads connect. This is given in the tables.

(5) Locate the reversing jumpers and tie them together temporarily. The location of the slots in which the reversing jumpers fall is given in the tables.

(6) Locate the conductors forming each of the short pitches in the order given in the table. Clip these

Table VI—Four-Pole, Three-Phase Windings

These tables give the arrangement for a series-star connection. To obtain a series-delta connection, connect A and B_1 to one line lead, B and C_1 to second line lead and C and A_1 to third line lead.
For a left-hand winding number slots in a clockwise direction.
For a right-hand winding number slots in a counter-clockwise direction.
"Top" refers to top conductor in slot; "bottom" refers to bottom conductor in slot.
In the last column to the right are given the number of short jumper (S. J.) clips.
Tables VI-X give layouts that will bring the line leads as close together as possible.

No. of Coils	Coils Per Section	Coils Per Group	Pitch	Leads Top A	B	C	Star Top A_1	B_1	C_1	Reversing Jumpers Bottom to Bottom	Short-Pitch Connections Connect Bottom to Top	No. S. J. Clips
24	4	2	1 & 7	1	9	17	19	3	11	(12- 18)(20-2)(4-10)	(19-24) (13-18) (3-8) (21-2) (11-16) (5-10)	6
36	6	3	1 & 10	1	13	25	28	4	16	(17- 26)(29-2)(5-14)	(27- 35, 28- 36)(18- 26, 19- 27)(3-11, 4-12)(30-2, 31- 3)(15- 23, 16- 24)(6-14, 7-15)	12
48	8	4	1 & 13	1	17	33	37	5	21	(22- 34)(38-2)(6-18)	(35- 46, 37- 48)(23- 34, 25- 36)(3-14, 5-16)(39-2, 41- 4)(19- 30, 21- 32)(7-18, 9-20)	18
60	10	5	1 & 16	1	21	41	46	6	26	(27- 42)(47-2)(7-22)	(43- 57, 46- 60)(28- 42, 31- 45)(3-17, 6-20)(48-2, 51- 5)(23- 37, 26- 40)(8-22, 11-25)	24
72	12	6	1 & 19	1	25	49	55	7	31	(32- 50)(56-2)(8-26)	(51- 68, 55- 72)(33- 50, 37- 54)(3-20, 7-24)(57-2, 61- 6)(27- 44, 31- 48)(9-26, 13-30)	30
84	14	7	1 & 22	1	29	57	64	8	36	(37- 58)(65-2)(9-30)	(59- 79, 64- 84)(38- 58, 43- 63)(3-23, 8-28)(66-2, 71- 7)(31- 51, 36- 56)(10-30, 15-35)	36
96	16	8	1 & 25	1	33	65	73	9	41	(42- 66)(74-2)(10-34)	(67- 90, 73- 96)(43- 66, 49- 72)(3-26, 9-32)(75-2, 81- 8)(35- 58, 41- 64)(11-34, 17-40)	42
108	18	9	1 & 28	1	37	73	82	10	46	(47- 74)(83-2)(11-38)	(75-101, 82-108)(48- 74, 55- 81)(3-29, 10-36)(84-2, 91- 9)(39- 65, 46- 72)(12-38, 19-45)	48
120	20	10	1 & 31	1	41	81	91	11	51	(52- 82)(92-2)(12-42)	(83-112, 91-120)(53- 82, 61- 90)(3-32, 11-40)(93-2, 101-10)(43- 72, 51- 80)(13-42, 21-50)	54
132	22	11	1 & 34	1	45	89	100	12	56	(57- 90)(101-2)(13-46)	(91-123, 100-132)(58- 90, 67- 99)(3-35, 12-44)(102-3, 111-11)(47- 79, 56- 88)(14-46, 23-55)	60
144	24	12	1 & 37	1	49	97	109	13	61	(62- 98)(110-2)(14-50)	(99-134, 109-144)(63- 98, 73-108)(3-38, 13-48)(111-2, 121-12)(51- 86, 61- 96)(15-50, 25-60)	66
156	26	13	1 & 40	1	53	105	118	14	66	(67-106)(119-2)(15-54)	(107-145, 118-156)(68-106, 79-117)(3-41, 14-52)(120-2, 131-13)(55- 93, 66-104)(16-54, 27-65)	72
168	28	14	1 & 43	1	57	113	127	15	71	(72-114)(128-2)(16-58)	(115-156, 127-168)(73-114, 85-126)(3-44, 15-56)(129-2, 141-14)(59-100, 71-112)(17-58, 29-70)	78
180	30	15	1 & 46	1	61	121	136	16	76	(77-122)(137-2)(17-62)	(123-167, 136-180)(78-122, 91-135)(3-47, 16-60)(138-2, 151-15)(63-107, 76-120)(18-62, 31-75)	84
192	32	16	1 & 49	1	65	129	145	17	81	(82-130)(146-2)(18-66)	(131-178, 145-192)(83-130, 97-144)(3-50, 17-64)(147-2, 161-16)(67-114, 81-128)(19-66, 33-80)	90
204	34	17	1 & 52	1	69	137	154	18	86	(87-138)(155-2)(19-70)	(139-189, 154-204)(88-138, 103-153)(3-53, 18-68)(156-2, 171-17)(71-121, 86-136)(20-70, 35-85)	96
216	36	18	1 & 55	1	73	145	163	19	91	(92-146)(164-2)(20-74)	(147-200, 163-216)(93-146, 109-162)(3-56, 19-72)(165-2, 181-18)(75-128, 91-144)(21-74, 37-90)	102

Table VII—Six-Pole, Three-Phase Windings

See heading of Table VI for instructions on using table.

No. of Coils	Coils Per Section	Coils Per Group	Pitch	Leads Top A	B	C	Star Top A_1	B_1	C_1	Reversing Jumpers Bottom to Bottom	Short-Pitch Connections Connect Bottom to Top	No. S. J. Clips
18	3	1	1 & 4	1	5	9	16	2	6	(13- 16) (17-2) (3- 6)	None	0
36	6	2	1 & 7	1	9	17	31	3	11	(24- 30) (32-2) (4-10)	(31-36) (25-30) (3-8) (33-2) (11-16) (5-10)	6
54	9	3	1 & 10	1	13	25	36	4	16	(35- 44) (47-2) (5-14)	(45- 53, 46- 54) (26-34, 27-35) (3-11, 4-12) (48-2, 49- 3) (15-23, 16-24) (6-14, 7-15)	12
72	12	4	1 & 13	1	17	33	41	5	21	(46- 58) (62-2) (6-18)	(59- 70, 61- 72) (27-38, 29-40) (3-14, 5-16) (63-2, 65- 4) (19-30, 21-32) (7-18, 9-20)	18
90	15	5	1 & 16	1	21	41	46	6	26	(57- 72) (77-2) (7-22)	(73- 87, 76- 90) (28-42, 31-45) (3-17, 6-20) (78-2, 81- 5) (23-37, 26-40) (8-22, 11-25)	24
108	18	6	1 & 19	1	25	49	51	7	31	(68- 86) (92-3) (8-26)	(87-104, 91-108) (29-46, 33-50) (3-20, 7-24) (93-2, 97- 6) (27-44, 31-48) (9-26, 13-30)	30
126	21	7	1 & 22	1	29	57	56	8	36	(79-100) (107-2) (9-30)	(101-121, 106-126) (30-50, 35-55) (3-23, 8-28) (108-2, 113- 7) (31-51, 36-56) (10-30, 15-35)	36
144	24	8	1 & 25	1	33	65	61	9	41	(90-114) (122-2) (10-34)	(115-138, 121-144) (31-54, 37-60) (3-26, 9-32) (123-2, 129- 8) (35-58, 41-64) (11-34, 17-40)	42
162	27	9	1 & 28	1	37	73	66	10	46	(101-128) (137-2) (11-38)	(129-155, 136-162) (32-58, 39-65) (3-29, 10-36) (138-2, 145- 9) (39-65, 46-72) (12-38, 19-45)	48
180	30	10	1 & 31	1	41	81	71	11	51	(112-142) (152-2) (12-42)	(143-172, 151-180) (33-62, 41-70) (3-32, 11-40) (153-2, 161-10) (43-73, 51-80) (13-42, 21-50)	54
198	33	11	1 & 34	1	45	89	76	12	56	(123-156) (167-2) (13-46)	(157-189, 166-198) (34-66, 43-75) (3-35, 12-44) (168-2, 177-11) (47-79, 56-88) (14-46, 23-55)	60
216	36	12	1 & 37	1	49	97	81	13	61	(134-170) (182-2) (14-50)	(171-206, 181-216) (35-70, 45-80) (3-38, 13-48) (183-2, 193-12) (51-86, 61-96) (15-50, 25-60)	66

Table VIII—Eight-Pole, Three-Phase Windings

See heading of Table VI for instructions on using table.

No. of Coils	Coils Per Section	Coils Per Group	Pitch	Leads Top A	B	C	Star Top A_1	B_1	C_1	Reversing Jumpers Bottom to Bottom	Short-Pitch Connections Connect Bottom to Top	No. S. J. Clips
24	4	1	1 & 4	1	5	9	22	2	6	(19- 22) (23-2) (3- 6)	None	0
48	8	2	1 & 7	1	9	17	43	3	11	(36- 42) (44-2) (4-10)	(43-48) (37-42) (3-8) (45-2) (11-16) (5-10)	6
72	12	3	1 & 10	1	13	25	64	4	16	(53- 62) (65-2) (5-14)	(63- 71, 64- 72)(54- 62, 55- 63)(3-11, 4-12)(66-2, 67- 3)(15-23, 16-24)(6-14, 7-15)	12
96	16	4	1 & 13	1	17	33	85	5	21	(70- 82) (86-2) (6-18)	(83- 94, 85- 96)(71- 82, 73- 84)(3-14, 5-16)(87-2, 89- 4)(19-30, 21-32)(7-18, 9-20)	18
120	20	5	1 & 16	1	21	41	106	6	26	(87-102) (107-2) (7-22)	(103-117, 106-120)(88-102, 91-105)(3-17, 6-20)(108-2, 111- 5)(23-37, 26-40)(8-22, 11-25)	24
144	24	6	1 & 19	1	25	49	127	7	31	(104-122) (128-2) (8-26)	(123-140, 127-144)(105-122, 109-126)(3-20, 7-24)(129-2, 133- 6)(27-44, 31-48)(9-26, 13-30)	30
168	28	7	1 & 22	1	29	57	148	8	36	(121-142) (149-2) (9-30)	(143-163, 148-168)(122-142, 127-147)(3-23, 8-28)(150-2, 155- 7)(31-51, 36-56)(10-30, 15-35)	36
192	32	8	1 & 25	1	33	65	169	9	41	(138-162) (170-2) (10-34)	(163-186, 169-192)(139-162, 145-168)(3-26, 9-32)(171-2, 177- 9)(35-58, 41-64)(11-34, 17-40)	42
216	36	9	1 & 28	1	37	73	190	10	46	(155-182) (191-2) (11-38)	(183-209, 190-216)(156-182, 163-189)(3-29, 10-36)(192-2, 199- 9)(39-65, 46-72)(12-38, 19-45)	48
240	40	10	1 & 31	1	41	81	211	11	51	(172-202) (212-2) (12-42)	(203-232, 211-240)(173-202, 181-210)(3-32, 11-40)(213-2, 221-10)(43-72, 51-80)(13-42, 21-50)	54

These Rules for Laying Out Wave Windings Were Derived in the First Two Articles of this Series

Rule 1—The number of coils in a series is equal to one-half the number of poles in the winding.

Rule 2—The number of series of coils equals the number of slots per pole per phase, which is equal to the number of slots divided by the number of poles and this result divided by the number of phases.

Rule 3—The number of sections equals twice the number of phases; that is, each phase will have two sections.

Rule 4—The number of coil groups is equal to the number of poles multiplied by the number of phases.

Rule 5—Between the starting and finishing leads of each section there will occur a number of short pitches equal to one less than the number of slots per pole per phase.

Rule 6—The reversing jumper lead (that is, R_1, R_2, R_3, R_4, R_5, etc.) and the finishing lead of the phases (that is, A_2, B_2, C_2) are on the left of their respective phase starting lead (that is, A_1, B_1, C_1), for a left-hand winding and on the right for a right-hand winding.

Rule 7—The first reversing jumper of a phase (that is, R_1 for A phase, R_3 for B phase, or R_5 for C phase) will be located in a slot that is a number of slots from the phase starting slot (A_1, B_1, or C_1, as the case may be) equal to the front pitch plus one less than the number of coils per group, measured in a counter-clockwise direction for a left-hand winding and measured in a clockwise direction for a right-hand winding. Also, if the starting lead (A_1, B_1, or C_1) goes to a top conductor, then the reversing jumper lead is connected to a bottom conductor.

Rule 8—The second reversing jumper lead for a given phase (R_2, R_4, or R_6) is connected to a bottom coil half or conductor when the first reversing jumper is connected to a bottom conductor and *vice versa*, and is spaced one front pitch measured in a counter-clockwise direction from the first reversing jumper for a left-hand winding and measured in a clockwise direction for a right-hand winding.

Rule 9—The finishing lead of a phase (A_2, B_2, or C_2), will connect to a conductor located in a slot that is one front pitch from the starting lead of that phase and is measured in a counter-clockwise direction for a left-hand winding and in a clockwise direction for a right-hand winding.

Rule 10—If the starting lead of a phase connects to a top conductor or coil half, then the finishing lead of that phase will connect to a top conductor, or *vice versa*.

Rule 11—In a left-hand winding having more than one coil per cell and in which the line leads are to be connected to top conductors, the line leads must connect to the top conductors on the right-hand side of the slot, while the reversing jumpers connect to bottom conductors on the left-hand side of the slot. When the line leads connect to bottom conductors, the bottom conductors on the left-hand side of the slot must be used and the reversing jumpers will connect to top conductors on the right-hand side of the slot. The opposite holds true for a right-hand winding; that is, with line leads connecting to top conductors, use left-hand top conductors, and the reversing jumpers will connect to right-hand bottom conductors. Also, if the line leads connect to bottom conductors, use right-hand bottom conductors for line leads and connect the reversing jumpers to left-hand top conductors.

Rule 12—When there is more than one coil per cell, we pass completely around the winding as many times as there are conductors or coil sides per cell before we use the short front pitch.

conductors together as fast as they are located.

(7) Locate, by means of a test light, the other coil half or conductor of the coil to which the A-phase line lead is connected. Also, locate the top conductor that is two back pitches measured in the same direction the slots are numbered, from the conductor to which the A-phase line lead connects. This will locate the second coil of the first series. These two conductors should be clipped together. Using this as a starting point, clip the unconnected adjacent top and bottom conductors together all around the winding.

As an example of how the tables are to be used, let us lay out a left-hand, two-layer, winding for a four-pole, two-phase motor, having twenty-four coils and twenty-four slots. The first thing to do is to locate the slot that is on the center line of the terminal block. In Fig. 1 on page 555 assume that this is the slot marked *X*.

This is the slot for the B_1 lead. In Table I on the second line, which is for a twenty-four-coil winding, we find that the B_1 lead falls in slot *16*; hence we are able to number the slots in the manner shown in the diagram. Since the winding is to be left hand, the slots should be numbered in a clockwise direction. The winder should face the connection side of the stator when marking the numbers on the slots.

The coils should now be put in the stator in the proper group formation. According to the table, there are three coils per group; hence the first and third or last coil of each group should have phase insulation.

The conductors to which the line leads connect, should be located next. According to the table, they are all top conductors and are located in the following slots: A_1 in slot *1*, B_1 in slot *16*, A_2 in slot *19* and B_2 in slot *10*. This is shown in detail in Fig. 1 on page 555.

The reversing jumpers should now be located and tied together temporarily. According to Table I, one reversing jumper should connect the bottom conductors in slots *11* and *17* together (R_1 to R_2 in Fig. 1) and the other reversing jumper should connect the bottom conductors in slots *2* and *8* (R_3 to R_4 in Fig. 1).

The short-pitch connections should be located next. According to the table, the first short-pitch connection occurs between the bottom conductor in slot *18* and the top conductor in slot *23*; the second short-pitch connection occurs between the bottom conductor in slot *19* and the top conductor in slot *24*, and so on through the remaining six short-pitch connections. The short-pitch connections are indicated in Fig. 1 by the asterisks. These conductors should be connected together as fast as they are located.

By means of a test light, locate the second conductor of the coil to which the A-phase, line lead connects. The A-phase, line lead connects to the top conductor in slot *1*. By the test light, we find that the other coil side or conductor of this coil (coil *a1*) is the bottom conductor in slot *7*. This conductor is to be connected to the top conductor two full back pitches from slot *1* measured in the same direction in which the slots are numbered. This second conductor will fall in slot *13*. Using this as a starting point, clip together in a similar manner the remaining, unconnected adjacent top and bottom conductors.

After the rules for wave windings are understood, it is a simple matter to arrange a winding table for any number of coils, phases, and poles. In constructing such a winding table, there are several things about the winding that must be known at the start. They are: the number of phases; the number of poles; the number of slots; the number of coils; whether the winding is to be right hand or left hand; and whether the leads are to connect to top or bottom conductors in the slots. As an example, let us calculate the winding data for a two-phase, four-

Table IX—Ten-Pole, Three-Phase Windings

See heading of Table VI for instructions on using table.

No. of Coils	Coils Per Section	Coils Per Group	Pitch	Leads Top A	Leads Top B	Leads Top C	Star Top A_1	Star Top B_1	Star Top C_1	Reversing Jumpers Bottom to Bottom	Short-Pitch Connections Connect Bottom to Top	No. S. J. Clips
30	5	1	1 & 4	1	5	9	28	2	6	(25- 28) (29-2) (3- 6)	None	0
60	10	2	1 & 7	1	9	17	55	3	11	(48- 54) (56-2) (4-10)	(55-60) (49-54) (3-8) (57-2) (11-16) (5-10)	6
90	15	3	1 & 10	1	13	25	82	4	16	(71- 80) (83-2) (5-14)	(81- 89, 82- 90)(72- 80, 73- 81)(3-11, 4-12)(84-2, 85-3)(15-23, 16-24)(6-14, 7-15)	12
120	20	4	1 & 13	1	17	33	109	5	21	(94-106) (110-2) (6-18)	(107-118, 109-120)(95-106, 97-108)(3-14, 5-16)(111-2, 113-4)(19-30, 21-32)(7-18, 9-20)	18
150	25	5	1 & 16	1	21	41	136	6	26	(117-132) (137-2) (7-22)	(133-147, 136-150)(118-132, 121-135)(3-17, 6-20)(138-2, 141-5)(23-37, 26-40)(8-22, 11-25)	24
180	30	6	1 & 19	1	25	49	163	7	31	(140-158) (164-2) (8-26)	(159-176, 163-180)(141-158, 145-162)(3-20, 7-24)(165-2, 169-6)(27-44, 31-48)(9-26, 13-30)	30
210	35	7	1 & 22	1	29	57	190	8	36	(163-184) (191-2) (9-30)	(185-205, 190-210)(164-184, 169-189)(2-23, 8-28)(192-2, 197-7)(31-51, 36-56)(10-30, 15-35)	36
240	40	8	1 & 25	1	33	65	217	9	41	(186-210) (218-2) (10-34)	(211-234, 217-240)(187-210, 193-216)(3-26, 9-32)(219-2, 225-8)(35-58, 41-64)(11-34, 17-40)	42

Table X—Twelve-Pole, Three-Phase Windings

See heading of Table VI for instructions on using table.

No. of Coils	Coils Per Section	Coils Per Group	Pitch	Leads Top A	Leads Top B	Leads Top C	Star Top A_1	Star Top B_1	Star Top C_1	Reversing Jumpers Bottom to Bottom	Short-Pitch Connections Connect Bottom to Top	No. S. J. Clips
36	6	1	1 & 4	1	5	9	34	2	6	(31- 34) (35-2) (3- 6)	None	0
72	12	2	1 & 7	1	9	17	67	3	11	(60- 66) (68-2) (4-10)	(67-72) (61-66) (3-8) (69-2) (11-16) (5-10)	6
108	18	3	1 & 10	1	13	25	100	4	16	(89- 98) (101-2) (5-14)	(99-107, 100-108)(90- 98, 91 - 99)(3-11, 4-12)(102-2, 103-3)(15-23, 16-24)(6-14, 7-15)	12
144	24	4	1 & 13	1	17	33	133	5	21	(118-130) (134-2) (6-18)	(131-142, 133-144)(119-130, 121-132)(3-14, 5-16)(135-2, 137-4)(19-30, 21-32)(7-18, 9-20)	18
180	30	5	1 & 16	1	21	41	166	6	26	(147-162) (167-2) (7-22)	(163-177, 166-180)(148-162, 151-165)(3-17, 6-20)(168-2, 171-5)(23-37, 26-40)(8-22, 11-25)	24
216	36	6	1 & 19	1	25	49	199	7	31	(176-194) (200-2) (8-26)	(195-212, 199-216)(177-194, 181-198)(3-20, 7-24)(201-2, 205-6)(27-44, 31-48)(9-26, 13-30)	30
252	42	7	1 & 22	1	29	57	232	8	36	(205-226) (233-2) (9-30)	(227-247, 232-252)(206-226, 211-231)(3-23, 8-28)(234-2, 239-7)(31-51, 36-56)(10-30, 15-35)	36
288	48	8	1 & 25	1	33	65	265	9	41	(234-258) (266-2) (10-34)	(259-282, 265-288)(235-258, 241-264)(3-26, 9-32)(267-2, 273-8)(35-58, 41-64)(11-34, 17-40)	42

pole, stator having thirty-two slots and coils and having the line leads connected to top conductors in the slots. The winding is to be left hand. The data and calculation will be tabulated as follows:

(1) Number of slots—32.
(2) Number of phases—2.
(3) Number of poles—4.
(4) Number of coils—32.
(5) Number of sections, according to *Rule 3* (given in the box on page 536) is equal to $2 \times 2 = 4$.
(6) Number of coil groups according to *Rule 4*, equals $2 \times 4 = 8$.
(7) Number of coils per section equals total number of coils divided by the total number of sections, or $32 \div 4 = 8$. This checks with the value given in the third line and second column of Table I.
(8) Number of coils per group equals total number of coils divided by the number of coil groups, or $32 \div 8 = 4$. This gives the value given in the third line and third column of Table I.
(9) According to *Rule 5*, there will occur in each section a number of short-pitch connections equal to one less than the number of slots per pole per phase; that is, there will be a number of short-pitch connections equal to $[(32 \div 4) \div 2] - 1 = 3$.
(10) The total winding pitch equals total number of slots divided by half the number of poles, or $32 \div 2 = 16$; that is the total winding pitch will be 1-and-17.
(11) The back pitch is equal to one half of the winding pitch, or $16 \div 2 = 8$, which is a back pitch of 1-and-9.
(12) The front pitch is equal to the total winding pitch minus the back pitch, or $16 - 8 = 8$, which is a front pitch of 1-and-9. Items 11 and 12 check the value given in the third line and fourth column of Table I.
(13) The pick-up pitch is used in locating the conductor which is the end of the first section of a phase; that is, it is the conductor from which the reversing jumper starts. According to *Rule 7*, this conductor is located in a slot that is a number of slots from the phase-starting slot equal to the front pitch plus one less than the number of coils per group. Consequently, the pick-up pitch equals $8 + 4 - 1 = 11$; that is, a pick-up pitch of 1-and-12.
(14) The short pitch is equal to one slot less than the front pitch; that is, it is equal to $8 - 1 = 7$, or a pitch of 1-and-8.
(15) As we have said before in this article the A_1 lead will connect to a conductor in slot *1*. It could go into any other slot, but for simplicity in laying out the winding, we will locate it in slot *1*. We have decided at the start of this calculation that the winding is to be left-hand and that the leads are to go to top conductors; therefore, the A_1 lead will connect to the top conductor in slot *1*. This is the slot number given in the third line and fifth column of Table I.
(16) The A_2 lead will connect to a top conductor that is in a slot one back pitch measured in a counter-clockwise direction from the A_1 slot. Since the A_1 lead connects to a conductor in slot *1* and since there are thirty-two slots in this stator, slot *1* is the equivalent of slot *33* and, therefore, the A_2 lead will be found as follows: 33–8=25. The A_2 lead will connect to the top conductor in slot *25*, which is the slot number given in the third line, seventh column of Table I. This is in accordance with *Rule 9*.
(17) The conductor to which the B_1 lead connects will be a number of slots measured in a clockwise direction from the A_1 slot (slot *1*) equal to two times the front pitch plus the number of coils per group. Therefore, the conductor to which the B_1 lead connects will fall in $1 + (2 \times 8) + 4 = 21$, or slot *21*. This checks the slot number given in the third line, sixth column of Table I.
(18) According to *Rule 9*, the conductor to which the B_2 lead connects will fall in a slot that is one front pitch measured in a counter-clockwise direction from the B_1 slot; that is, 21–8=13. Therefore, the conductor to which the B_2 lead will connect falls in slot *13*. According to *Rule 10* it will connect to a top conductor in that slot. This checks the slot number given in the third line, eighth column of Table I.
(19) As said before in this article and in accordance with *Rule 7*, the R_1 lead will fall in a slot that is one pick-up pitch measured in a counter-clockwise direction from the A_1 slot; that is, slot *1*, or, what is equivalent to it, slot *33*. The pick-up pitch is 11; then $33 - 11 = 22$; consequently, the R_1 lead will connect to a bottom conductor in slot *22*.
(20) According to *Rule 8*, the second reversing-jumper lead for a given phase in a left-hand winding will fall one front pitch measured in a counter-clockwise direction from the first reversing-jumper lead, or $22 - 8 = 14$. Therefore, the R_2 lead will connect to a conductor that is located in the bottom of slot *14*.
(21) In a manner similar to that used in item 19, we find that the R_2 lead will connect to a bottom conductor in slot *10*, for the B_1 lead falls in slot *21* and the pick-up pitch is equal to *11*, and $21 - 11 = 10$.
(22) In a manner similar to that used in item 20, we find that R_4 falls in the bottom of slot *2*, for the R_3 conductor falls in slot *10* and the front pitch is equal to 8; then $10 - 8 = 2$. The slot numbers given in items 19, 20, 21 and 22 check the data given in the third line, ninth column of Table I.

If we examine Fig. 1 we will notice that there are two short-pitch connections that start from slots that are located (*Continued on page 554*)

INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

DANIEL H. BRAYMER
Editorial Director

Assisted by

G. A. VAN BRUNT F. E GOODING A. J. WHITCOMB

Chicago, November, 1924

Know What Material Handling Actually Costs

ONE of the most difficult problems incidental to persuading industrial men to change the method of performing any operation lies in convincing them that the new way is the better way. This is particularly true in material handling. Here traditional practices of carrying materials on two-wheeled hand trucks or by methods unsuited, in the light of modern developments, to the conditions of load and distance, are still altogether too common.

This work has been performed largely by common labor. In the United States it has always been easy to hire this labor whenever needed and to fire it when conditions were such that it was no longer required. Many industrial men have come to believe that this is the cheapest and best way of handling the situation.

Due to the present order of things, particularly the tightening up of immigration, this privilege of hiring and firing is past. Many concerns continue to attempt this method and when they learn that they cannot secure proper labor they still hesitate about substituting mechanical methods of handling material because of the apparently high first cost. This cost, in spite of their opinion, is today not sufficiently high to give the desired return in proportion to the risk and engineering necessary to carry on the development of new types of equipment to meet the demands of economical handling, and also to cover the expense of missionary work in persuading the prospective user of its advantages.

Probably the prime reason for all this is that trucking has usually been considered as a non-productive operation. These costs have crept into the general overhead and no real record has ever been maintained, so that the employer of labor has had no real knowledge of the actual expense attached to the handling of material in process. Naturally, therefore, in making a capital expenditure, such as he is called upon to authorize in the purchase of equipment, this operation is next put on the productive schedule, and even though the saving be great, it is very difficult to learn exactly what it is, due to lack of proper cost keeping for the hand operation. Thus he has no actual figures for comparison.

Those industrial men who are faced with the problem of revamping their material-handling methods will find it to their advantage to first make a careful analysis of what is done and how much it costs. This will provide the basis for a study of new methods and equipment available and a check on their performance.

He Cannot Read His Tombstone When He's Dead

FOR what follows we would like to have the ear of employers. We recently had our attention called to an advertisement eulogizing an employee who had died after twenty years of faithful service. This was a nice touch of sentiment for an association of two decades, but the unfortunate fact about it is that it came too late. The heirs and assigns probably read that advertisement with much satisfaction, but the man who was moved, by an unquestionably high motive, to spend the company's money in this way forgot that his associate could not read his tombstone when he's dead.

A tangible token of appreciation for faithful service during a man's lifetime would cost no more than a newspaper advertisement and there can not be the least doubt that such recognition to a living worker is worth more to all concerned than a newspaper full of eulogizing advertisements dedicated to dead ones.

Some organizations have adopted a service emblem that is a mark of special recognition worn by men who for definite and known reasons merit it. It is not a substitute for more money, but a supplement to it in the form of a reward—not a wage. The difference is considerable. The wage is in payment for services rendered, while the emblem award is a recognition for something more than hours of service; it covers loyalty, faithfulness and devotion to duty—things that cannot be purchased with legal tender.

The service emblem and all it stands for is within the reach of all employees and it's simply a pity that more executives do not set it up as a thing worth while working for, since it costs nothing but may mean much to those who merit it.

Plant Service Is as Strong as Its Weakest Link

IN A paper presented before the annual convention of the Association of Iron and Steel Electrical Engineers, J. F. Kelly gives the following relation between production and maintenance in the iron and steel industry:

The steel industry today is as strong or as weak as its maintenance departments and, argue as you will, its success or failure in any plant is largely due to the manner in which its maintenance departments are organized and equipped. What matters it if your plant can boast of the most modern installations unless you have provided the necessary tools for its upkeep? In a very short time your plant will be subject to annoying costly delays, which interfere with your production schedules, and consequently you are not making profits—but producing at a loss.

You say these are self-evident facts, but in making up budgets for your board of directors, how often is it the case when the estimates are pruned, that the maintenance departments receive the least consideration, and sometimes no consideration at all? There have been instances in the history of the steel industry where fabulous sums were ex-

pended for buildings, mill equipment, power houses; and yet practically no money set aside, worth mentioning, for maintenance departments, with the result that these modern plants were continually being delayed, first by minor breakdowns—then major ones; production was seriously handicapped, all due to the fact that no provisions had been made for maintenance. Here are glaring examples of too much mill—too little shop.

Maintenance, the steel industry will always have with it, and this fact must be fully recognized by the managements, if they desire their production schedules maintained. Maintenance departments are responsible for the continuity of operation, for the development of apparatus which will produce the large tonnages desired, yet too often is this most salient fact overlooked.

Accepting this as a basis for argument, why is it that so little effort and so little importance are attached to seeing that these departments are equipped with all of the modern improvements, calculated to preserve the continuity of operation?

On every hand we hear, first, "Increase your production"; second, "Lower your costs"; third, "Reduce your stores supply." The answer to this it would seem is:

Organize your maintenance departments and equip them with the same careful analysis you devote to your production problems; if your mills are always prepared to operate, it naturally follows your production will not suffer.

What holds true in the steel mills holds true for all industry. Organize your maintenance department, not with the thought that it is so much overhead which must be kept at a low figure, but with the idea that it is a producing department, producing continuous operation, economical performance, and development of ideas or apparatus for larger production.

Be Sure The New Man Understands His Job

EVERY now and then a new, although supposedly experienced, man will make a mistake or an error in judgment that is difficult to understand. He has claimed to be experienced along certain lines and has proved it by references from former employers, or otherwise. In the face of all this something goes wrong and the cause is eventually traced back to the recently employed man.

Perhaps he is inexcusably at fault, but before this decision is reached and action taken, oftentimes a summary dismissal, it is advisable for the foreman or someone higher in authority to see if the newcomer was given a fair chance. The fact that a man is experienced does not always mean all that it seems to imply. Methods, policies and conditions vary considerably in different plants, so that when a workman goes from one plant to another he may have a good deal to learn, even though he is engaged in the same general line of work. Naturally he wants to make the best possible impression and sometimes rather than admit that he does not fully understand what is to be done, or how to do it, he uses his own judgment—which may or may not be good. In the latter event the results are disappointing all around.

Foremanship involves a good deal more than merely assigning jobs to the workmen. Almost anyone can do that. The real foreman will always make sure that a workman, particularly a new one, not only understands what is wanted and how it should be done, but is capable of doing it. It is unfair to everyone concerned, and poor policy in general, to turn a new man loose on his job without definite assurance that he understands the work fully and is in every way qualified to do it in the proper manner, without instruction.

It's Everybody's Job to Prevent Accidents

SAFETY from the point of view of the executive was so ably presented by B. F. Affleck, President of Universal Portland Cement Company of Chicago in an address at the thirteenth annual Safety Congress recently held at Louisville, Ky., that we want to quote verbatim a few things he said as follows:

Notwithstanding the great improvement which has been made since the beginning of the safety movement, there is still a great deal of room for improvement in guards and various devices to keep employees away from danger. But as I see it the particular place where there is most room for improvement is in the training and education of the employee.***

Prevention of accidents is, I need scarcely tell you, a large and difficult proposition. It is one on which much more information and advice can be obtained from the novice than from the expert. In other words, the difficulties are less apparent to the outsider than to the man who is called upon to remove them. Executive officers have a great responsibility with respect to accident prevention. They are responsible for providing the means for education in safety, to teach restraint and consideration for the safety of others, and they must realize that they cannot shift the burden of final responsibility.***

In carrying on accident prevention activities there should, of course, be a comprehensive safety organization consisting of officials, foremen and workmen, because if safety work is to be a success it must be everybody's job to prevent accidents.

Mr. Affleck put his finger on a vital point, we believe, when he said, "It must be everybody's job to prevent accidents." So much attention is so often paid to speeding up production and cutting down its costs that the part played in this work by lost-time accidents is not always given due consideration. Entirely aside from the loss that can be expressed in dollars, resulting from frequent lost-time accidents, there is an even greater loss that is hard to make up in changes in the production organization through fatal injuries to trained men and the fear that quickly grows up in an operating force that certain departments are dangerous and undesirable places in which to work.

To illustrate the importance of these viewpoints, Mr. Affleck quoted from letters by Judge Gary, President of the U. S. Steel Corporation, to presidents of subsidiary companies, in which he said that there would be no hesitation in making the necessary appropriations of money to carry into effect every suggestion that seemed to be practicable for the improvement of conditions in their mills. In this connection he pointed out that much can be done by designing new construction and machinery with all practical safeguards. "Nothing," said Judge Gary, "which will add to the protection of workmen should be neglected, for the safety and welfare of our workmen is of the greatest concern." As a practical illustration that he meant what he said, a total of $126,885,911 was spent for safety and welfare work from January 1, 1912 to January 1, 1923 through the suggestions and co-operation of 84,491 men who have served on safety committees. At the present time 10,331 men in the Steel Corporation are serving on safety committees and from January 1, 1912, have brought about a reduction of better than 70 per cent in all disabling accidents.

This saving in man-power and improvement in conditions under which they work is truly of great concern to American industries and it's the job of every one engaged therein to do a part, from workman to chief executive.

Questions Asked and Answered by Readers

Here is a place where you can get some inside information when you get stuck. The only restriction is that you do a good turn to the other fellow when he asks a question that you can answer from your experience.

Practical Pete

Who Can Answer These?

Lining Up Sprockets for Chain Drives—Can some reader tell me the best and simplest method of lining up sprockets, or shafts, for chain drives? We frequently change machines around and install new drives or replace old ones, and I should like to be sure that we are lining these up properly.
Decatur, Ill. J. L. B.

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Motor-Generator Set for Testing Small Single-Phase and Three-Phase Motors—Will some reader please tell me what capacity motor-generator set (d.c. motor—a.c. generator), method of drive and style of generator I could use for testing single-phase and three-phase, 60-cycle, 220-volt motors up to 1 hp. rating? Is it possible to change over from 25 cycles to 60 cycles, from 110 to 220 volts and from single phase to three phase, or the reverse, just by means of throwover switches? What changes would have to be made in the motor and generator in order to secure 25-cycle current? What capacity would be obtained from a 60-cycle set delivering 25-cycle current?
Chicago, Ill. E. J.

• • • •

Commutator Trouble with Interpole Motor—I have a 15-kw., six-pole, compound-wound, interpole exciter, for a synchronous motor, that has three black and somewhat flat spots at equal intervals around the commutator. This machine has a lap winding and the mica is not undercut. There is always some sparking at the brushes. If I shift the brushes, the black spots move in the direction the brushes are shifted. I lifted the leads from their risers at each spot and tested for open circuits with a test lamp, but everything seemed to be O. K. Will some reader please suggest a cause and the remedy for this trouble?
St. Croix Falls, Wis. K. A.

• • • •

Operating 25-Cycle Transformers on a 60-Cycle Circuit—We are operating a 2,300-volt, sixty-cycle, three-phase system and in a short time will be called upon to furnish some additional lighting and power service. Our present transformers are not sufficiently large to handle this additional load and we do not wish to purchase new ones as the load will be on for only a few days. We can rent 2,300-volt, twenty-five-cycle transformers and I should like to know if these will work satisfactorily on the sixty-cycle current. Will the secondary voltage be the same as on twenty-five cycles? If not how much will it be below normal?
Carthage, Mo. A. P. K.

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Why Can Not This Motor Be Speeded Up?—We have a Westinghouse, type SK, 7½-hp., 1,150-r.p.m., 110-volt motor that is giving us trouble. The nameplate says "Shunt Wound, Continuous Speed," but it has a series field, shunt field and interpoles. For several years this motor ran satisfactorily, until a brush was replaced. The new brush was identical with the old one.

The motor picks up regularly and carries the load, but as soon as the field is weakened to increase the speed the load fluctuates badly; the more the field is weakened the more the load swings until there is a sharp flash at the brushes or a fuse blows. All kinds of connections have been tried, without results. The speed of the motor when running the machine is from 1,150 to 1,500 r.p.m. When the trouble started the machine was running at 1,800 r.p.m. The same trouble occurs with all of the different motors of the same type that we have tried on this machine, although it can be driven satisfactorily by a straight shunt motor of less horsepower rating. Can some reader tell me the cause of this trouble?
Norwood, Mass. E. F.

• • • •

Starting Trouble with Motor-Generator Set—In starting a synchronous motor-generator set the motor field is first short-circuited by the double-pole, double-throw, quick-break switch, which is provided with a short-circuiting resistance contact that closes just before the switch is opened from one direction and opens just before the switch is closed in the other position. The motor is started and comes up to speed on 2,000 volts; the field switch is then thrown to obtain excitation from the 250-volt bus. The running voltage of 6,600 volts is then applied. When the field switch is thrown from starting to running positions there is a bad flash between the hinge clips and the short-circuiting resistance jaw. What is the cause of this flash and how may it be avoided?
Pittsburgh, D. W. B.

Answers Received To Questions Asked

Trouble Caused by Plugging Elevator Motor—Will some reader of INDUSTRIAL ENGINEER please give me some help on the following problems? (1) We have a 10-hp., 550-volt, three-phase elevator motor which is controlled by a Cutler-Hammer reversing switch. We are experiencing a good deal of trouble from blowing of fuses due to reversing the motor before the elevator comes to a full stop. This elevator has no regular operator and is used for freight service only. Has anyone had similar trouble and what is the best method of overcoming it? (2) Is it possible to wind a magnet that will lift from 10 to 25 lb. and can be operated on a 110-volt, sixty-cycle circuit? If so, please give me the winding data for 110 volts and also 550 volts.
Millbury, Mass. L. A. T.

Referring to the question by L. A. T. in the October issue, I would say that the trouble is probably the result of poor adjustment of the brake on the elevator machine. It would be advisable, at any rate, to inspect the brake mechanism on this machine and see that it stops the machine promptly and without too much sliding. Without more detailed data as to the scheme of connections it is hardly possible to advise L.A.T. much more on this point.

In reference to his second question, I would say that it is quite possible, and not at all difficult to wind a magnet for operation on 110 volts a.c., to lift 10 to 25 lbs. But before determining the winding data, it is necessary to know the dimensions of the magnetic circuit and the space available for the winding.
Honesdale, Pa. J. M. WALSH.

• • • •

Referring to L. A. T.'s questions in the October issue of INDUSTRIAL ENGINEER it appears that a drum-type, rope-operated, reverse switch is being used with apparently no main switch. There are several types of reverse switches manufactured, and from what is said it would appear that there is no main switch to break the circuit at the time the drum is moved in the neutral or central position. It is very possible that the centering device has shifted on the drum shaft so that when stopping it breaks the circuit in one direction and moves through the neutral into the reverse, plugging the motor; then further action on the drum returns it to the off or neutral position. I suggest checking up the travel of the rope-operated sheave wheel and centering device with respect to its position in the drum. If a main switch were connected the opening of the circuit in the drum would drop out the main contactor and prevent an inrush of current in case the centering device throws the segments of the drum to the extreme reverse position. It might also be that the motor is not properly fused, and I suggest that this be checked to see if 30 amp. fuses are being used. It is also suggested that the solenoid or motor-operated brake be checked to see that it is functioning properly at the time of stopping.

I trust that the above information will be of some help to L. A. T., and if he desires further detailed information suggest that he write directly to the Cutler-Hammer Mfg. Company giving the serial number of the control equipment and explaining the difficulty he is having.

If the second question refers to a lifting magnet, the answer is No; but if the question pertains to a solenoid magnet used to lift a given amount attached to a lever or valve, the coil can be wound for both 550 volts and 110 volts, alternating current. No mention is made as to whether it is to be used for continuous or intermittent duty, and since the coil data depends upon the design of the frame, it is difficult and would be practically useless to give any coil-winding data. To make up an a. c. solenoid magnet, laminations are required which are riveted together under hydraulic pressure and fitted to a steel frame. Such work rquires apparatus usually not available in the average shop, and we believe that such magnets can be purchased at a fair price and much cheaper than they could be made.

I shall be glad to give L. A. T. any information that I can, regarding the types and sizes of magnets now on the market, if he will write to me or to the Editors of INDUSTRIAL ENGINEER.

E. H. LAABS.

Engineer, Printing Equipment Dept.,
The Cutler-Hammer Mfg. Co.,
Milwaukee, Wis.

* * * *

Why Do These Commutators Turn Black?—I am experiencing a great deal of trouble from blackening of the commutators on two G. E. belt-driven, type ML, compound-wound, 125-volt, 950-r.p.m., 13 kw., d.c. generators which are used as exciters. After smoothing with sand paper, it is only a matter of a few hours until the commutators are in the same condition again. I have tried turning the commutators in a lathe and undercutting the mica, polishing, sanding, using Ideal commutator stone and tightening the commutator. Also, I have used four different grades of brushes and am now using Speer E-25 brushes. There is no sparking at all under varying loads. The setting of the brush holders was changed from leading to trailing and I found that they worked best leading. I have tried the brushes at different angles and found that the best results were obtained when they were set at about 80 deg.

We wipe off the commutators once each day with a dry piece of canvas. I have checked the brushes for the neutral position. The tension on the brushes is 1½ lb. per sq. in. The temperature seems normal except when the commutators get very black as they will do if they go about a week without sanding. These exciters are only two years old and have been in actual service about one year each. I have had this trouble from the start.

I shall appreciate it very much if some reader of INDUSTRIAL ENGINEER can tell me what the trouble is and how I may cure it.

Woodward, Okla. H. J. A.

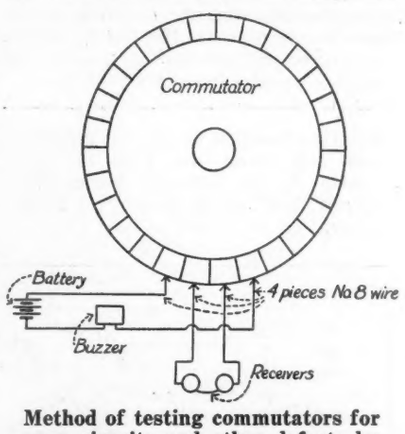
In reply to the question by H. J. A., in the August issue of INDUSTRIAL ENGINEER, from the information given it is quite evident that the trouble cannot be diagnosed very easily. Not being as familiar with this trouble as the people in the immediate vicinity I would not attempt to say what the trouble is except that it is probably inherent in the design or some difficulty either in the casting or a variation in the materials used in the generators, making these machines somewhat different from the average run of the particular type of generator in question. This is not unusual, as we frequently encounter such conditions.

However, as to the cure, we have cured such cases in the past by the use of a high-contact resistance brush with an abrasive action. The high contact resistance tends to reduce the blackening by limiting the current more nearly to the load current, and cutting down the cross-bar currents. The abrasiveness of the brush takes the place of the sand paper which is used once a week. I believe that this condition can be cured by the use of the proper brushes and I would be glad to co-operate with H. J. A. from this standpoint.

Pure Carbon Co.,
Wellsville, N. Y. R. J. COLEBERT.

* * * *

Answering H. J. A.'s question in the August issue, in most cases blackening of commutators is caused by excessive sparking at the brushes, or by too much lubricant. Sparking does not seem to be the cause of the trouble in this case, however, for H. J. A. states that his machines do not spark at the brushes. I would suggest, however, that he test his armatures to find out if there are any defects in them. This can be done by means of a pair of wireless telephone receivers, two dry cells and a buzzer, connected as shown in the diagram. I have found that four pieces of No. 8 wire about 8 in. long, bent



Method of testing commutators for open circuits and other defects by means of a buzzer and telephone receivers.

over slightly on the end, insulated from each other with tape and then taped together so that each will touch a segment in the middle, make convenient testing leads. When testing with this outfit start at a marked segment and test each segment around the commutator. If the coil or segment under test is normal, there will be a clear buzz in the receivers. In case there is a poor connection or open circuit there will be a buzz in the receivers about twice as loud as is obtained normally. With a short circuit there will be no sound.

When testing for a ground, place one of the buzzer leads on the frame of the machine under test and connect the other lead to the commutator; also connect one of the telephone receiver leads to the machine frame and with the other lead touch each segment until one is found that gives no sound in the receivers. The one that gives no sound is the grounded coil or segment.

I would also advise checking the position of the brushes. This will require the use of a low-reading volt meter, say five or six volts. Take a dry, wooden block, cut it into the shape of a brush and through it drill two small holes that will reach the center of two adjoining commutator bars. Place in these holes two pieces of lead out of a pencil, and to these pieces connect the voltmeter leads. Take out one of the regular brushes and put the wooden brush in its place. Then run the generator under light load but at full speed and rated voltage and shift the brushes backward and forward until the point is found where the voltmeter gives the minimum reading. This is the neutral point and the machine should work well when the brushes are set on this point.

I would also suggest that the commutator segments be counted and the brushes spaced so that they have the same number of segments between them.

The use of commutator lubricant is bad policy after commutators have been undercut, as it causes carbon and dust to collect between the segments. Oil will sometimes come from the shaft and gather on the commutator and produce similar troubles. Washing the commutator with benzine and letting it dry thoroughly is about the only remedy for this condition.

As to grinding commutators, I do not consider this good practice to follow very frequently, as it is very difficult to hold any form of grinding stone so as to cut the commutators true and they soon get out of round which, in turn, is another cause of commutator trouble.

Galesburg, Ill. EARL BABER.

* * * *

Referring to the commutation troubles reported by H. J. A., in the August issue, in connection with two ML compound-wound exciters rated at 112 amp., 125 volts, 950 r.p.m., I would like to suggest that he try operating these at 125 volts instead of 95 volts as reported. It would also be advisable to check the speed and make sure that the exciters are not operating at more than 950 r.p.m.

The design of these particular exciters is such that the best results will be obtained when they are operating at rated voltage and rated speed. If either the voltage is low or the speed is high, trouble may be experienced.

C. M. FULK.

Central Station Engineering Dep't.,
General Electric Co.,
Schenectady, N. Y.

* * * *

Advantages of Star- and Delta-Connected Motor Windings—I wish someone would kindly give me some information on the following questions. Why are some three-phase motors star-connected, and some delta-connected? What are the advantages of a star-connected motor over one that is delta-connected? I shall appreciate it very much if someone will explain this to me.

Toledo, Ohio. F. H.

Referring to the question by F. H. in the September issue of INDUSTRIAL ENGINEER, I believe there is no way to predict the form of the stator windings of an induction motor. Whether it is star or delta connected depends entirely on the designer who first lays out the machine. A motor of a certain horsepower, speed, and voltage requires a certain flux or magnetic density. This flux density can be obtained by varying the pole pitch, number of conductors,

and by using a star or delta connection. Sometimes the best combination is obtained by a star connection, and sometimes by a delta connection. The number of slots in a certain size motor may give the best results by using a star connection and a certain number of coils. Another rating may lend itself best to the delta connection. Of course, if a certain rating, say 20 hp. 1,200 r.p.m., 60 cycles, 220 volts, by a certain manufacturer, is found to be delta connected it is pretty safe to predict that all other motors of this rating by this manufacturer are also delta connected. However, a duplicate rating by another manufacturer might be star connected, because another designer may have decided to use a different combination of slots, coils and winding.
Schenectady, N. Y. ROGER F. EMERSON.

* * * *

In reply to the question by F. H. in the September issue, if we take two motors, one star- and the other delta-connected, of the same size, same horsepower and wound for the same voltage, we will find that the efficiency will be the same; or we can take the motors and change the type of winding on them and still get the same results. Thus, it would appear that one winding is as good as the other. But on examination we will find that the star winding has fewer turns of a larger-size wire than the delta winding has; in other words the delta winding will have a greater number of turns of smaller-size wire.

Now if we take a delta-connected motor wound for 100 volts and reconnect it star, we will have a motor suitable for 173 volts, which means that the star connection will stand 1.73 times as much voltage as the delta connection. Then for high voltages the star connection is superior to the delta, inasmuch as there are fewer turns of wire in the coils and less slot insulation is required.
Muncie, Ind. GEORGE CROPPER.

* * * *

In answer to F. H.'s question in the September issue, I would say that a motor has to be designed to operate either star or delta connected. That is, the connection cannot be changed haphazardly.

The real advantage of a star connection over a delta connection is found in high-voltage machines. In a motor the slots are small and it is difficult to insulate the coils from the stator. In any case the more copper there is in a slot, the better. Therefore, with a star connection, the voltage per coil is only 58 per cent of the line voltage. If a motor is rated at 2,300 volts the voltage per coil will be only $2,300 \div 1.73 = 1,330$ volts, for which the coil will have to be insulated. In a delta connection the voltage per coil is the same as the line voltage and in this instance the coils have to be insulated for 2,300 volts. Therefore, the coils in a delta-connected motor have to be more thoroughly insulated than in a star-connected motor.

Labor and insulation are expensive; so any reduction which can be made in either, represents a saving.
Revere, Mass. PAUL FEENEY.

How Should This Machine Be Placed?—It is common practice to place a pulley at right angles to a lineshaft which, of course, means that the belt has no twist in it. However, we have a 125-ton press and would like to place it in such a position that the pulley on this press will be 45 deg. from the lineshaft. I should like to know, (1) if this is an unusual way of running a belt, and (2) how should the machine be placed with the pulley in this position, so that the belt will not be continually slipping off.
Philadelphia, Pa. A. T. S.

Replying to A. T. S. in the August issue, (A) in the illustration shows the relative location of the shafts, pulleys and belt. Also, (SP) represents the lineshaft pulley and (MP) the machine pulley, the center lines of whose axes lie in different horizontal planes, but at an angle (x) instead of being parallel, as is usually the case. It is possible, and practicable, to install pulleys for any value of (x) between zero and 180 deg., provided the shaft centers are sufficiently separated.

For successful operation it is essential that plane (MM') of the lineshaft pulley and plane (NN') of the machine or driven pulley intersect so that points (b) and (c) will lie in both planes. Point (b) is the point of tangency between the belt and the machine pulley where the belt leaves the pulley. Point (c) is the corresponding point of tangency on the lineshaft pulley.

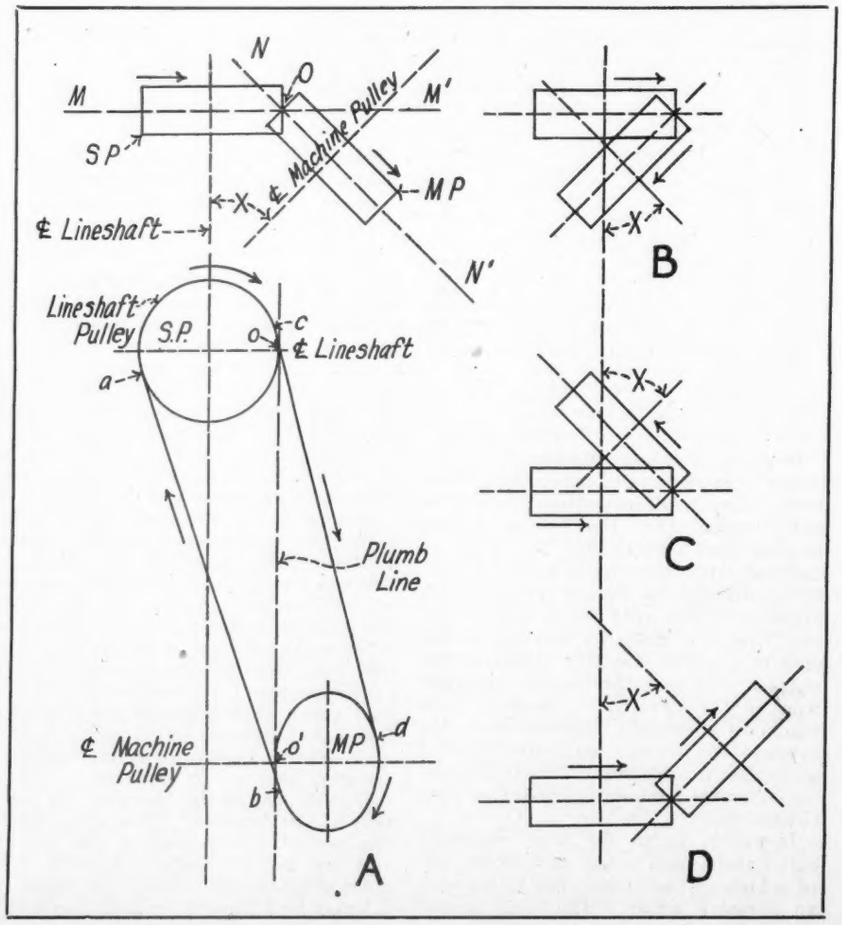
Relative location of shafts, pulleys and belt when the axes of the shafts lie in different horizontal planes and at an angle to each other.

It can be stated, in general, that the point on a pulley where a belt leaves it must be so located that the belt will be delivered to the center of the face of the receiving pulley. If this condition is rigidly adhered to there will be no difficulty in installing pulleys at any angle, provided the centers are sufficiently spaced and the shafts do not lie in the same plane. From this it is evident that in a given installation the direction of rotation of the pulleys is not reversible.

If the pulleys are both very nearly the same size the approximate location can be determined by dropping a plumb line from point (o) on the lineshaft pulley and placing the machine pulley tangent to the plumb line. In order to get the exact location it may be necessary to move the machine a little to compensate for the slight differences in position of points (o) and (c) and (o') and (b) on the pulleys.

For each angle (x) there are four possible positions in which the machine or driven pulley may be placed relative to the lineshaft pulley. In two of these positions the machine pulley will be driven in one direction and be reversed in the other two positions. In the illustration (B), (C) and (D) show the three positions and direction of rotation not shown in (A).

It should be noted that the point at which the belt leaves the pulley is a controlling feature in installations of this sort. If attention is paid to this no trouble should be encountered in the solution of the problem.
Wilmington, N. C. CHAS. R. SUGG.



How Does Change in Speed of Motor Affect Horsepower?—I shall appreciate it if some reader of INDUSTRIAL ENGINEER can answer the following question: We have a 3-hp., 3,600-r.p.m. motor which we are changing to operate at 1,800 r.p.m. I should like to know what the approximate horsepower of the motor will be after this change, if we use the same number of turns of the same size wire in the stator.
Enid, Okla. C. E. S.

In reply to the inquiry by C. E. S. in the August issue, he does not state whether this is a d.c. or an a.c. motor. Assuming that it is an a.c. machine, changing it from 3,600 to 1,800 r.p.m. using the same size of wire and the same number of turns in the stator as before, would not be very satisfactory. When changing the speed of motors remember that the counter e.m.f. is higher at high speeds than at low speeds and the turns are, therefore, less for high speeds.

In rewinding this motor for 1,800 r.p.m. wind it for four poles, with twice the number of turns and half the size of the wire in the present winding. The horsepower will be approximately 1½.
Los Angeles, Calif. H. A. NIELSEN.

* * * *

In reply to C. E. S. in the August issue, the horsepower will decrease in direct proportion to the decrease in speed, assuming that you use the same size of wire. In your case the new horsepower will be $1,800 \times 3 \div 3,600 = 1.5$ hp., but if you change from two poles to four poles to get 1,800 r.p.m., you will have to change the connections of the motor. If it is now two-circuit star or delta, you will have to change it to single-circuit star or delta, as on half speed, 1,800 r.p.m., it will only produce one-half of the counter-electromotive force that it would on 3,600 r.p.m.

The chord factor must also be considered. Say your motor has thirty-six slots; then full pitch would be $36 \div 2 = 18$, or slots (1) and (19), and the chord factor would equal 1. Now on four poles, it would be $36 \div 4 = 9$ or slots (1) and (10). The motor would then be over-pitch which has the same effect as under-pitch. The four-pole chord factor would be only .707 which would cause the motor to run hot. Therefore, it would be advisable to rewind the motor with the proper chord factor and use twice the present number of turns with half the wire size. Use the same chord factor, from full pitch, that the two-pole winding now has and connect the motor for the same number of circuits that it had before, assuming that you desire to use the same voltage as before. Of course, you can, if you have room in the slots, use larger wire and thereby increase your horsepower. If you use a little less insulation and single-cotton-covered wire, you should be able to get a larger wire in the slot.
NICHOLAS J. WEISS.
West New York, N. J.

* * * *

In answer to C. E. S.'s question in the August issue, I am taking it for granted that this is a polyphase motor. Then, hp. = (torque × r.p.m.) ÷ 5252.

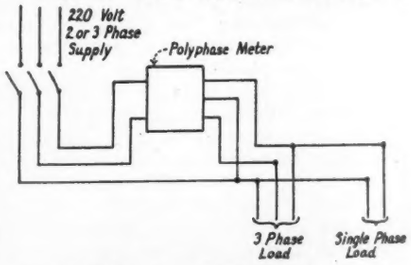
The motor as originally wound developed 3 hp. at 3,600 r.p.m. It will, therefore, develop 1½ hp., when reconnected for 1,800 r.p.m., because the torque has not been changed and the speed has been reduced one-half. The torque cannot be changed very materially for the core is so designed that the motor will produce its full torque when the magnetic density is nearly at the limit.

A change in speed must be accompanied by a change in the applied voltage. Assume, for example, that this 3-hp. 3,600-r.p.m., three-phase motor has thirty-six coils, two poles and is connected series star. When it is changed to four poles, 1,800 r.p.m., we still have thirty-six coils and the same number of turns per coil with a series-star connection, but the rotating magnetic field is only making 1,800 r.p.m. instead of 3,600 r.p.m. Then the counter-electromotive force will be reduced one-half. This would allow approximately twice the normal current to flow through the stator winding, which would soon be burned out.

If the motor were connected double star, it could be reconnected series star for operation at 1,800 r.p.m., and would give fair results on the original voltage. Or the original connection could be used and the motor operated on one-half the original voltage. Of course, other connections could be used, but I have cited these merely as examples.
Galesburg, Ill. EARL BABER.

* * * *

Single-Phase Load on Polyphase Meter—Will some reader of INDUSTRIAL ENGINEER please tell me what will be the difference, if any, in the real power consumption as compared with the meter reading when a single-phase load and a polyphase load are taken from one polyphase meter, as shown in the diagram. The polyphase load seems to



be registered correctly, but will the meter register too much when single-phase power is used? If so, would the same result be obtained on both two-phase and three-phase circuits?
Northampton, Mass. L. G. D.

In answer to L. G. D. in the August issue, when a single-phase load is connected to a polyphase meter, there should be no difference between the power consumed and the amount recorded on the meter, provided, of course, that the meter is accurate and is connected properly. Connecting a single-phase load on a polyphase system, either two or three phase, results in an unbalanced system and all polyphase meters should record the true power consumed, regardless of whether the system is balanced or unbalanced.

Sometimes, however, polyphase meters are found to run a little fast or a little slow when operating on an unbalanced polyphase system, even though the connections are correct. Usually this is because the torques on the meter elements are unequal. The meter should be adjusted so that when the same amount of power is passed through each element, the torque on each is equal. If this is not done, when the meter is operating on an unbalanced system it will run too fast when one element has more of the load passing through it, and will run too slowly when the other element is carrying the heavier load. ERNEST DICKINSON.
Kimberley, B. C., Can.

* * * *

In answer to L. G. D.'s question in the August issue, a polyphase watt-hour meter which is connected correctly to measure two-phase or three-phase power will indicate the power consumed on the "load" side of the meter regardless of the condition of balance. Since the case presented is simply a two-or three-phase load which is unbalanced, due to the addition of the single-phase load to one phase, the meter will, if properly connected, correctly indicate the watt-hours consumed.
Toronto, Can. HERBERT KING.

* * * *

In the August issue of INDUSTRIAL ENGINEER, L. G. D. asked about the accuracy of metering when a single-phase load is connected to a polyphase meter.

In its present form his question is far from being clear, as he does not show the inside connections of the meter. However, I presume that this is the usual type of polyphase meter, which is essentially a combination of two single-phase meters. Such a meter is able to measure accurately a polyphase load even if the phases are unbalanced. The readings of the instrument will, therefore, be correct regardless of whether the single-phase load is taken alone or at the same time as the three-phase load. P. VAN HERK.
Liege, Belgium.

* * * *

Answering L. G. D.'s question in the August issue, there is no theoretical reason why this meter should not give an accurate record of the consumption of single-phase power, if it has been properly adjusted. A three-phase load rarely has a 100 per cent power factor and the torque on the two elements, therefore, is not the same; in other words, if two single-phase meters were installed in place of the polyphase meter they would not read alike unless the power factor were 100 per cent. In fact, at 50 per cent power factor one of the meters would read zero.

In any watt-hour meter an adjustment must be made for light loads and unless this is done the record of consumption at a low speed may be very much in error in one element.

The registration of a polyphase meter is dependent on the sum of the torques of the two elements and the addition of a single-phase load will, therefore, only add to the torque of the polyphase load in its proper phase relation and a correct reading will be obtained.

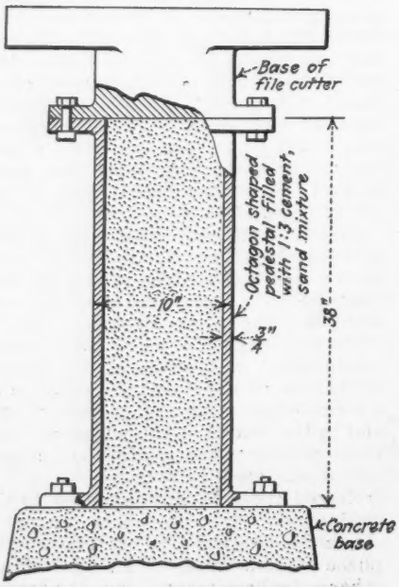
Should there be any doubt as to the accuracy of the polyphase meter it should be checked against two single-phase meters rather than against another polyphase meter, since the former would indicate with more certainty where the discrepancy, if any, exists.
C. OTTO VON DANNENBERG.
The J. G. White Engineering Corp.,
New York, N. Y.

Building Maintenance and Plant Safety

The object of this department is to give details of building maintenance procedure and best practice in safety work. Articles on ways of handling natural wear and tear or other depreciation, repair methods, rebuilding, extensions, cleaning and painting operations will always be welcome.

Concrete in Machine Pedestals Absorbs Hammer Shock

PRACTICALLY all file teeth are cut in special machines of the punch-press family with an open side in which a hammer weighing from 1 lb. to 100 lb. falls from 200 to 1,000 times a minute. The lower end of this hammer carries the chisel which cuts the annealed blank while the blank is fed along at a rate which produces coarse or fine teeth. In addition to the weight of the hammer itself, the power of a spring is put behind the hammer to make the right kind of a cut in the steel blank. Such pounding as this, all day long, demands a rigid machine and a husky foundation. It is customary to place a cast-iron pedestal between them and fastened to each. The general practice is to carry the throb of the file cutter down to a foundation in the ground.



Filling this pedestal between the machine bed and the foundation with a 1-to-3 cement-sand mixture insures, at low cost, greater rigidity of the machine.

The accompanying drawing shows a method now employed to secure mass and rigidity in the pedestals under such machines at a relatively low cost. The pedestals are filled with concrete after they are placed and bolted down.

As will be noted, the under side of the machine bed rests directly on the concrete inside the pedestal. This is purposely done to make it take its share of the load. On those machines that were made with a recessed center, a flat iron plate has been placed between base and pedestal to distribute this load over the entire surface.

A 3-to-1 mixture is used inside the castings without stone or cinders in it. The slight additional cost of using the richer mixture is fully justified. When it is desired to go further toward making a good job, the pedestals may be faced on the bottom and rested on a metal plate set in the foundations. Then although the pedestal practically rests on a machined surface a little thin cement is poured into the pedestal at first.

DONALD A. HAMPSON.
Plant Superintendent,
Morgans and Wilcox Mfg. Co.,
Middletown, N. Y.

Methods of Handling Fire Hose When Connecting Up

IN ORDER that the members of the fire department and other employees who are engaged in volunteer fire protection, may understand better the methods of handling a hose, The Pullman Company, Chicago, Ill., published in its shop paper, the accompanying illustrations showing how a hose should be handled. The upper illustration, for example, shows the two positions taken for unrolling a hose. The man on the right is using an underhand roll as in bowling, while the other is taking the position for what is known as the shoulder roll. The second illustration shows the completion of the roll. As the hose unrolls, the operator gives it a jerk to straighten out the 50-ft. length.

The third illustration shows the proper position for making a coupling.

Three steps in coupling a hose.

To show their employees how to handle fire hose, the Pullman Company have printed in their shop paper these three photographs which show how to unroll the hose, how to straighten it, and how to couple it.

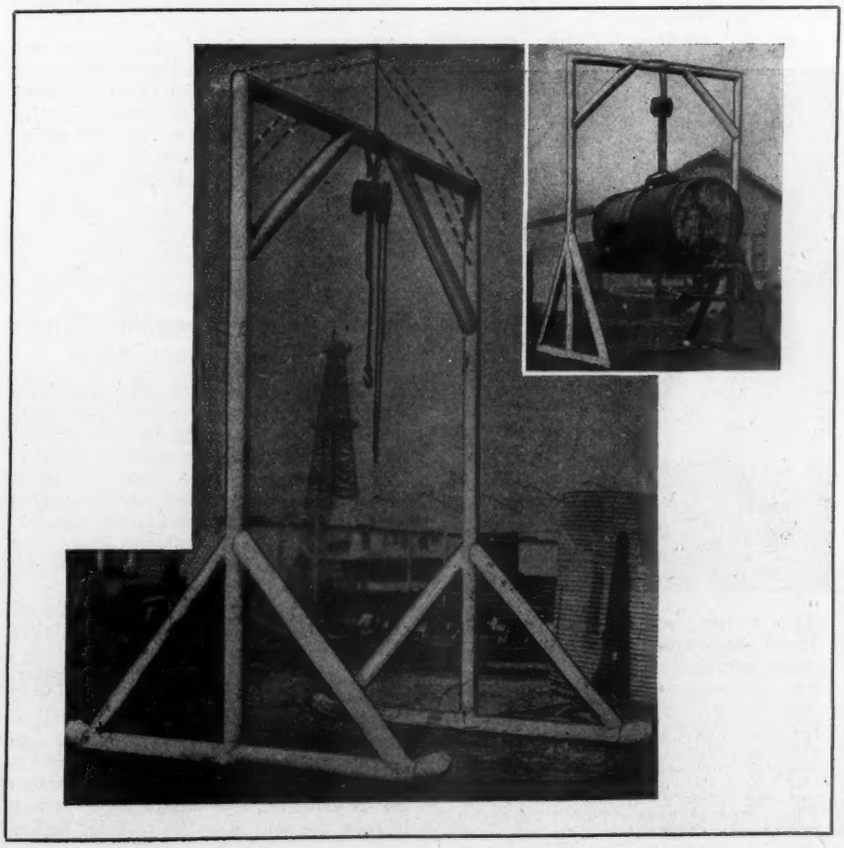
The "female" end of the coupling is held between the knees and the "male" end is held by the left hand with the right hand in position to turn up the coupling. Care must always be exercised so that the threads are not jammed nor the coupling started incorrectly, as in any case time is a very important element. Also, damaged threads may hold up getting the stream on the fire until it has made a good start.

Portable Derrick for Handling Miscellaneous Loads in Plant Yards

STORAGE yards usually contain a miscellaneous assortment of heavy materials which are difficult to load or unload by hand. Even though a large derrick may be located in the yard, it is not always available because it may not be within reach. As a result, wood "A" frames and various miscellaneous makeshift derricks are commonly used. While these serve the purpose, they are generally more or less unwieldy and are hard to move about and erect, as they often require guy ropes.

One oil company has devised an ingenious substitute for these makeshifts in the form of a derrick, shown in the accompanying illustration, which is fabricated entirely from pipe by oxy-acetylene welding, as recently explained in "Oxy-Acetylene Tips" issued by The Linde Air Products Co. The feet are bent up at the end to serve as skids on which the derrick is readily dragged from one location to another. The derrick is wide enough to straddle the object to be lifted whether it is on a motor truck or on the ground. The load is then hoisted by means of a chain block and the truck driven under or backed out and the load deposited on the ground. Loads that are not too heavy may be handled a short distance by lifting them and then dragging the loaded derrick to its new destination.

Actual fabrication of such a derrick may be left to a good welder but the design should be made by a trained engineer. For instance, while the derrick illustrated is probably capable of supporting any load within the range of the ordinary chain block, it could sustain a load several times as great if the top members were arranged in the form of a king post truss as shown by the dotted lines in the illustration at the left. In such a case the angular braces just under the cross bar could be shortened.



This portable derrick for supporting a chain block when handling yard material was made by an oxy-acetylene welder from scrap pipe.

Effect of Annealing Hoisting Sling Chains

IN a paper on the safe operation and use of hoisting chains, presented at the recent Safety Congress held at Louisville, Ky., A. V. de Forest, an engineer with the American Chain Company, Bridgeport, Conn., gave some interesting results that may be expected through annealing chains when an elongation indicates that they have been overloaded. Wear is sometimes a factor in causing elongation of a chain and it is necessary to distinguish between this effect and that of overload.

Regarding annealing when a chain does not show signs of wear, and why it tends to lower the working load but increases the factor of safety under shock, Mr. de Forest had the following to say:

"It is well known that annealing restores its original properties to cold-worked or distorted metal. At the same time it destroys the increased strength due to that cold work. As far as mitigating the effect of fatigue is concerned, it naturally can have no healing effect upon a failure already started, but it can and does lower the resistance to deformation.

"To illustrate: A 1-in. chain normally breaks at 60,000 lb. with 15 per cent elongation. A proof stress of 30,000 lb. will cause more elongation, but without careful measurement by inspectors the load could rise to 35,000 lb. with perhaps 6 per cent elongation. Repeated loads just below this figure would start fatigue cracks and final rupture without appreciable further elongation. If, after the first application of the 35,000-lb. load the chain had been annealed, it would start stretching at about 28,000 lb. and again would show nearly 15 per cent elongation, and if the 35,000 lb. were once more applied, the elongation would be so great that overloading would be self-evident. Here the annealing would act to protect the chain from further abuse. Suppose, however, that the loads repeatedly applied were 30,000 lb. and the chain were not annealed after its one application of the 35,000-lb. load. It would carry these loads without danger, but would have lost the 6 per cent elongation taken out by the 35,000-lb. load and the resulting greater shock-resisting power. Briefly, the annealed chain has greater resistance to breaking under a single shock load; the unannealed chain can stand a higher repeated load, and has a higher working strength, but does not have as great a resistance to a single shock.

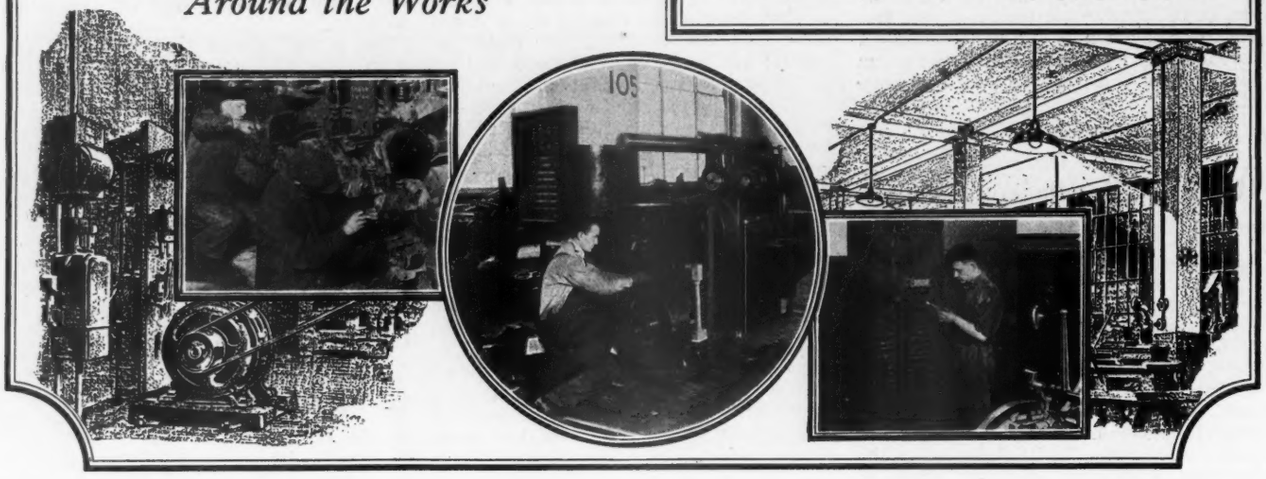
"The greatest benefit from annealing lies in the fact that it automatically increases the factor of safety. If improperly carried out, that is, if the chain is heated too hot, kept hot too long, or cooled too slowly, it weakens the chain. In general, it is only useful after the chain has been distorted by an overload and to lower the working load. It should not be done periodically as a "cure all," but, carried out in conjunction with careful inspection, it will add to the safety of lifting and hoisting operations.

"Annealing, however, can only restore ductility in the metal and does not affect the loss in elongation due to permanent deformation of the links. No chain should be used on important work after it has been badly overloaded and has thereby lost a considerable proportion of its remaining elongation. Its tensile strength may be unimpaired but its reserve of shock strength is gone. If annealing is carried out, the chain should be heated to a uniform temperature of between 1500° F. to 1600° F., kept at heat only long enough to reach this temperature throughout and cooled freely in air."

Electrical Service

Around the Works

For this section ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing or special installations.



Accessibility Is Important Factor in Maintenance of Lighting Units

THE usefulness of a reflector is easily and rapidly lost through the accumulation of dirt—and the measure of the value of the reflector is in the ability of its reflecting properties to bend the rays of light back and deliver them, without loss of intensity, between useful angles in the working area.

Obviously it is as necesary to restore these reflecting properties whenever they become impaired by dirt as it is to refill a gasoline tank when it becomes empty. It would be as absurd to build an automobile without making provision for refilling the tank as to install a reflector without making adequate provision for cleaning; nobody has ever found any kind of dirt that will save light.

And just because nobody thought to make provision for keeping them clean thousands of high-grade reflectors, all over the country, are now rotting away with dirt and rust, without performing the work for which they were purchased. It is dirt that destroys a reflector—for it is dirt that collects corrosive elements—and it is dirt that prevents the reflector from performing its proper function.

The greatest problem in lamp maintenance is accessibility, but this work can now be done easily and economically by installing the lamps on a safety lowering switch, or disconnecting hanger, enabling them to be lowered away from the electric circuit for the cleaning of reflectors and renewal of bulbs, thus eliminating climbing hazards and also eliminating all electrical hazards, by keeping the man entirely out of reach of the electric circuit.

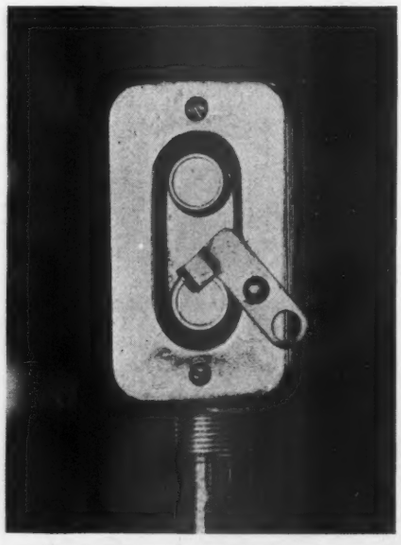
A perfectly clean bulb may be put into a dirty reflector without accomplishing anything, or at least not much; but it is a certainty that nobody is going to wash a reflector and polish it, without wiping off the bulb.

It is apparent therefore that there is no occasion for worrying about the bulb if the reflector is kept clean; for then the bulb will be taken care of automatically.

President, ALLISON J. THOMPSON.
The Thompson Electric Co.,
Cleveland, Ohio.

Method of Locking a Push-Button Station to Prevent Starting Motor

IN ONE of the departments of our factory, we are using an automatic starter for controlling a motor that drives a machine which extends through two floors. The motor is started from either floor from push-button stations and can be started only when all stations are clear. When working on, or loading up the machine, the operator pushes the stop button down and turns the clip shown in the accompanying illustration, over it. Since the control stations are electrically interlocked, this prevents anyone from starting the motor from either station. A hole is punched in one end of the clip so that a padlock may be slipped through it, thus locking the clip in this position and, consequently, locking the push-button in the stop position.



This device can readily be made from sheet steel and will prevent many accidents.

The photograph, which was furnished by the National Safety Council, shows the method of locking a push-button switch in the stop position. A padlock may be slipped through the hole in the clip, thus preventing unauthorized persons from starting the motor while workmen are working on the machinery driven by it.

The clip is made of sheet steel and is riveted or bolted to the push-button cover so that it may be turned around the rivet or bolt as is shown in the illustration. The end of the clip adjacent to the push button is formed so as to fit over the button when it is pushed in. H. H.

Columbian Rope Co.,
Auburn, N. Y.

Arrangement of Primary and Secondary Buses for Transformer Bank

MANY industrial works distribute their power supply at 550 volts and then transform it to 220 or 110 volts for use on the motors nearby. The transformers are usually placed outdoors on the ground. A very economical yet substantial arrangement of the high- and low-tension buses for such an installation is shown in the accompanying illustrations.

In Fig. 1 are shown two transformers connected open delta for supplying the 220-volt power required in the immediate vicinity. The 550-volt, primary bus is located on the wall behind the transformers. It consists of three single-conductor cables mounted on Pierce secondary racks (Hubbard & Co., Pittsburgh, Pa.) which are bolted to the face of 4-in. angle irons, which in turn are bolted to the wall by means

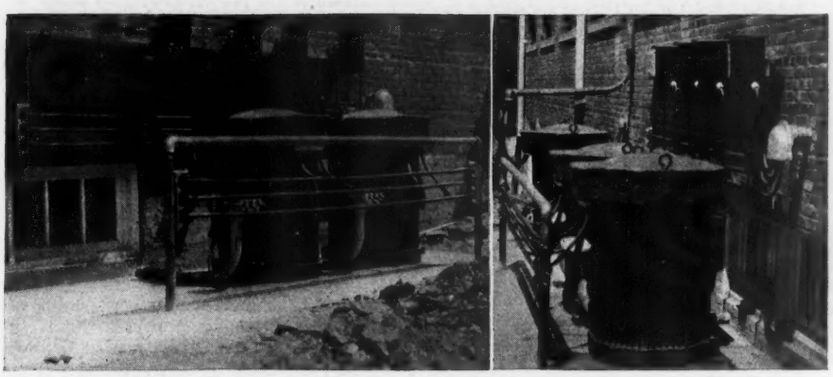


Fig. 1—The secondary bus of these transformers was mounted on a pipe frame-work.

In the left-hand illustration, may be seen how secondary racks were fastened to the pipe uprights in such a manner as to hold the buses made of single conductor cables. The right-hand illustration shows how a similar bus was mounted on the wall behind the transformers so as to supply the primary side of the transformers.

of through-bolts. When the cable buses are to be made up, the bolts fastening the Pierce secondary racks on one end are slacked off for about an inch and the bus cable made up as taut as possible in this position. The bolts on the slack secondary rack are then tightened up to the maximum which draws the buses up as tight as a "fiddle string." Thus tautness is obtained without the use of turnbuckles which take up much space and are not neat in appearance.

The 550-volt supply is delivered to the primary bus through wires in conduit as shown in the right-hand illustration of Fig. 1. A separate fuse cut-out is provided for each primary lead to the individual transformers. These cutouts are mounted on an angle iron which is above the primary bus and attached to the wall behind the transformers.

The arrangement of the secondary bus is unique. A pipe framework was mounted in front of the two transformers as is shown in the left-hand illustration of Fig. 1. A Pierce secondary rack is attached to each of the two pipe uprights and three single-conductor cables are strung to make the secondary bus, in a manner similar to that described for the primary bus. The pipe connecting the vertical members of the secondary-bus supports is provided, of course, for the sole purpose of giving something to pull against when the wires are tightened by the above mentioned method.

The secondary leads of the transformers are connected directly to the bus. Two feeders are shown connected to the secondary bus. They are in the two conduits running across the concrete floor on which the transformers are placed. In Fig. 2 is shown a similar arrangement for larger transformers. In this case the three large transformers are delta connected to supply the 220-volt power. The fourth transformer is a separate installation and supplies the 110-volt lighting system.

President,
Huntington & Guerry,
Greenville, S. C.
R. S. HUNTINGTON.

Fig. 2—Another installation using a pipe frame-work to support the secondary bus.

Notice the wire guard or grillework placed around the entire installation to provide greater safety. Also note the thorough grounding of the transformer cases by copper straps connected to ground plates. The ground connections can be seen on the front side of the concrete foundation.

Shocks from Lights Caused by Leaky Transformer Case

THE following incident, which occurred about a year ago in a machine shop in one of the larger cities, may be of interest to the readers of INDUSTRIAL ENGINEER. The street lines carried electrical energy at 2,200 volts, which was stepped down for domestic and industrial purposes. The machine shop mentioned operated its motors at 220 volts, three-phase, 60 cycles. The power transformer and the lighting-circuit transformer were both on the same pole in front of the shop, the pole having been set for this purpose and not to carry the power transmission lines.

One afternoon a workman in the grinding room reported to the superintendent that he was getting a shock from the lamp over his machine. The superintendent thanked the man, who had mentioned it as something of a joke, and said he would tell the electrician to go over the wires in the grinding room. Through some delay the electrician did not get around to it for several days and meanwhile there came a dark rainy day when lights had to be used quite generally.

This general turning on of lights started the fun. Men touched the keys and yelled; other men were knocked over. Fellow workmen laughed at those who had gotten a "shock" and, when taunted, tried the sockets themselves with the same result.

When the electrician was called, he made a hasty examination of the shop lines and could find nothing wrong. However, when he stood on a dry board and attempted to turn on a light (porcelain key on a porcelain socket), he was knocked against an adjoining partition. Realizing better than the rest that there was something radically wrong, he called up the line gang's office and the chief himself, skeptical and silent, showed up in a little while. This official refused to believe there was anything wrong and left saying that the boys imagined it, although he refused absolutely to try to turn on a light himself.

Not satisfied, the electrician called another department and got one of the meter testers to come out with a voltmeter. The floor in part of the machine shop was wood; the remainder was concrete. All of the floor was at the ground level. Selecting a socket where the concrete floor was right on the earth, the tester connected the meter between the socket and the floor. His instrument read 2,200 volts. He had found conclusively that there was something wrong.

When the line gang was forced by this test to look into the matter, they located it at the transformer. The latter was dry and entirely empty of oil, thus causing the insulation between the primary and secondary windings to fail and permitting the 2,200 volts to get on one of the low-voltage wires.

This is not, of course, a regular occurrence but it is worth watching out for and it goes to show that complaints about a "shock off of that light" ought not to be taken lightly. In this particular case, the oil had been leaking out gradually for some time. It was in the Spring and the branches of a maple tree swept the pole where the transformers were. The superintendent came right by the spot every day and he remarked, then, that he had noticed the spots on the sidewalk for some

time but thought they were from maple sap that had dropped from a broken branch above. DONALD A. HAMPSON.
Plant Superintendent,
Morgans and Wilcox Mfg. Co.
Middletown, N. Y.

Procedure for Inspecting and Maintaining Storage Batteries

THE operating code of the Philadelphia Electric Company contains the following instructions for treatment of cells whose voltage or specific gravity are seriously low:

1. When the plates of a cell become sulphated cut the cell out of service; substitute water for the electrolyte.

2. Charge the cell until there is no further increase in specific gravity.

3. If the sulphation is so deep as not to have been all removed by this operation, again substitute water for the electrolyte.

4. Charge the cell until there is no further increase in specific gravity.

5. Repeat this operation as often as may be necessary to remove the sulphation.

6. Bring up the specific gravity to the normal value by adding acid.

7. If the plates of a cell become short-circuited owing to bulging of the active material or foreign material between the plates, scrape the plates well with a stick. Remove the deposited material from the bottom of the jar.

8. If the plates of a cell become short-circuited owing to buckling, remove them from the cell and straighten them.

When scraping battery plates of accumulated materials a wooden stick should be used to avoid short-circuiting the plates. Owing to the considerable amount of moisture given off by a battery, the humidity in the battery room is very high and condensation occurs upon most objects, especially metal. This being acid in character causes corrosion of metal and also attacks the woodwork. Consequently acid-proof paint should be applied where possible, and vaseline should be used on parts such as connections between cells. Boiled linseed oil is also a good acid and moisture resistant for application to wood. Detailed instructions for cleaning and inspecting batteries, are as follows:

CLEANING AND INSPECTION

1. Wipe off glass covers, jars or tanks and all supporting insulation.

2. Keep the trays dry and clean.

3. After cleaning the wood tanks wipe them with a cloth saturated with boiled linseed oil.

4. Make sure that the overhanging lead on lead-lined tanks is pulled away from the sides of the tanks so that condensation will drop to the floor and not run down the sides of the tanks.

5. Coat the inside of the glass jars with vaseline about ½ in. down from the top.

6. Copper busbars and any other metal, except the connection between cells, which are exposed to acid fumes must be coated with acid-proof paint.

7. Wooden racks should have the same treatment.

8. The connections between cells should have a light coat of vaseline.

9. Wash the racks and the floor occasionally with bicarbonate of soda to prevent damage from acid.

10. Inspect the cells frequently for sulphation and internal short circuits.

11. Keep all material from bridging the space between the plates or building up on the bottom of the jar or tank. A wooden stick passed between the plates and scraped over the bottom of the jar or tank will prevent a dangerous accumulation of such material. Never use a piece of metal for this purpose.

12. Fill the automatic pilot cell filler as often as is necessary to replace evaporation.

Use of Extension Reel to Prevent Interruption of Telephone Service

ONE time when I was employed on an electrically-driven dredger, we were constantly bothered by interruption of the telephone service to the booster-station end of the shore line, when blow-outs of the rubber connections on the pontoon line occurred, or when the pontoon line pulled apart in stormy weather—just when telephone service was needed the most. The wires connecting the telephone stations were laid along the pontoons and when these were pulled apart the telephone lines broke also.

To get around this difficulty, I constructed a reel for the telephone wire and anchored it on the first pontoon; then when the pontoon line broke, the wire would just pay out and service would not be interrupted. Inasmuch as this wire reel could be built in almost any size and used to extend the range of portable tools or other light equipment, a description of it may be useful to other readers.

The illustration shows how this reel was made from an ordinary wooden reel upon which armature or banding wire is shipped.

An iron pipe was fitted tightly in the hole of the reel, to serve as a support, after holes for the conductor had been drilled through the reel and the pipe. The collector rings were made of brass tubing and were sawed off so that a lip was left, to which the telephone wire connections were soldered. These rings were put on by winding empire tape tightly around the pipe until the rings would fit very snugly over it by twisting them in the direction the tape was wound on.

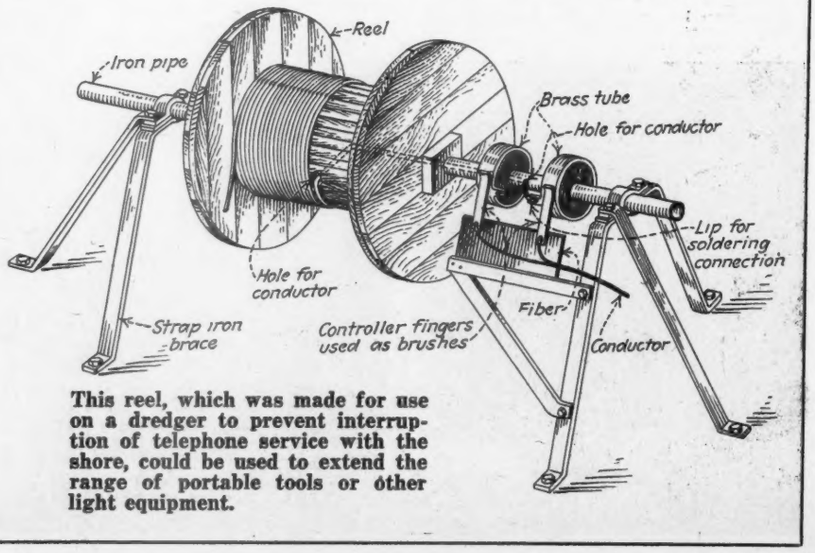
Probably a better looking job could have been made by mounting the collector rings on fibre disks turned down to the proper diameter, although rings mounted as described served our purpose well enough. When both rings were in place the lips were staggered. Another hole for the conductor was drilled in the iron pipe between the collector rings.

The pipe and reel were then mounted in simple bearings on a strap-iron support of the form shown in the illustration. These supports were easily made and were very strong.

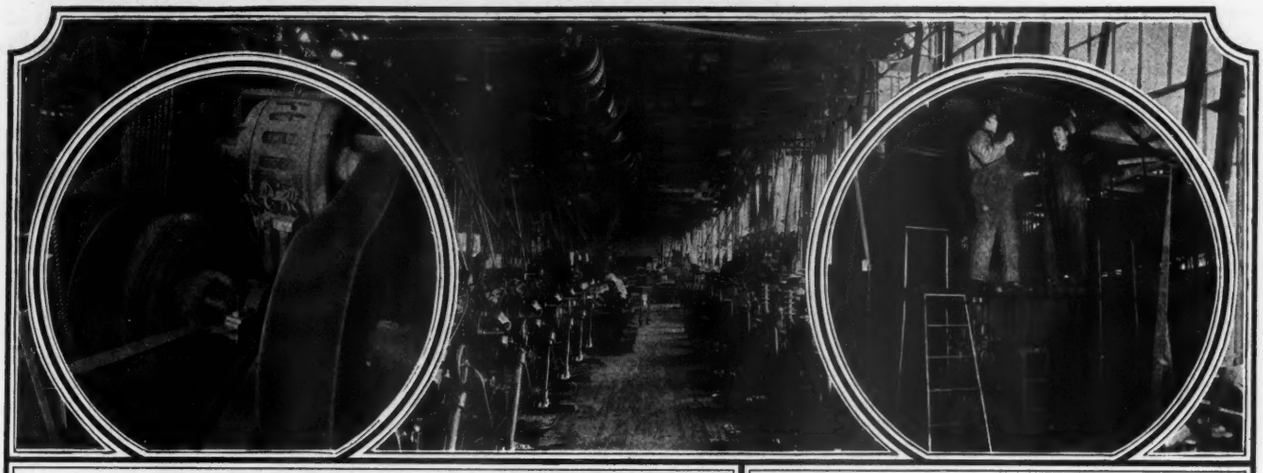
The brushes for the collector rings were made from old controller fingers with the solid copper tips removed. The strips of leaf copper remaining were riveted together and ground to fit the rings. These brushes were then bolted, spaced the proper distance apart, to a fibre block which, in turn, was securely bolted to the strap-iron bearing support.

The two wires comprising the dredger end of the telephone line were soldered to the collector ring brushes. One end of the conductor which was to be mounted on the reel was passed through the hole in the middle of the reel, through the pipe and out through the hole in the pipe between the collector rings, to which the two wires were soldered. The remainder of the wire was then wound up on the reel. The line to the shore was stretched along the pontoon line and passed through wired loops fastened to the pontoon pipe cleats. After this wire reel was put into service there was no further interruption of telephone communication with the shore.

Oakland, Calif. S. H. SAMUELS.



This reel, which was made for use on a dredger to prevent interruption of telephone service with the shore, could be used to extend the range of portable tools or other light equipment.



Mechanical Maintenance of Power Drives

This department will furnish mechanical details of installation, operation and maintenance of equipment in the path of power service from the first mechanical driving element through transmitting equipment to all driven machines.

Simple Brake to Stop Lineshaft Quickly in Emergency

A BRAKE that we installed on our machine shop line shafting is shown in the illustration. There are 180 ft. of shafting that drive nearly eighty countershafts. More or less work has to be done while shafts are running at normal speed or slackened for the occasion and there is likewise always the possibility of belts getting tangled up. A belt that gets caught may not injure a person, but after it breaks, flying ends may cause havoc until the shaft is stopped.

No means are provided to stop shafts in modern installations. It is not considered necessary—what is important is to make them run as easily, with as little power consumption, as possible and to this end the expense of ball bearings and non-slipping drives become justifiable. But the minute the power is shut off, the shaft load becomes unimportant—the shaft may run one minute or five in coming to a stop.

A brake like this will stop a lineshaft within a few revolutions after the power is shut off.

In an emergency, a brake is highly desirable. This one of ours has been used several times with gratifying results; one of the times being when a man got his hand tangled in a loose hanging belt, so that the brake changed what might have been a serious accident to merely a bad scare for everyone concerned. When it is necessary to stop the shaft during working hours to put on a belt, nearly a minute of each man's time is saved by being able to stop the shaft quickly.

The brake shown was made from an automobile brake. The supports and anchor were forged for this purpose and are bolted to a beam. Such a brake needs to be well supported in order to resist the tendency to wrap around the shaft when it is operated and also to keep it away from the drum, to avoid friction and heat. A lineshaft coupling or a small pulley may be used as the brake drum. The rod by which the brake is operated terminates in a handle that can be conveniently reached by a person standing on the floor.

DONALD A. HAMPSON.
Plant Superintendent,
Morgans and Wilcox Mfg. Co.,
Middletown, N. Y.

Advantages of Short Center Belt Drives in Industrial Plants

BELT capacity is ordinarily estimated with the assumption that the belt is in contact with at least 180 deg. of pulley surface. Where less contact is made less power can be transmitted with the belt at the same tension. Short-center drives require some means of increasing the belt wrap on the smaller pulley so that it will get more surface in contact with the small pulley and permit full capacity of transmission without excessive tension. One method of obtaining this is through special, belt-tensioning devices; one type of these is the "Pulmax Drive" designed by the engineers of the Bird Machine Co., South Walpole, Mass.

Drives of this general type are of particular value for transmission between pulleys that are unequal in size. The greater the difference in pulley size or the nearer the pulleys to each other, the greater the importance of this drive. With it higher efficiencies are now obtainable between a large and small pulley, placed close together, than are obtained from most ordinary drives that are regarded as ideal. In addition, with this type of drive the user of belts need no longer worry about relative pulley sizes, position of pulleys, vertical or horizontal, belt slip, which is the driver and which the driven pulley, or placing the pulling side on the top or bottom when planning a belt drive.

A typical drive of this sort of which the Pulmax is an example is shown in an illustration on the next page and consists of a roller (A) assembled on an arm (B) which in turn is mounted on a shaft (C) supported by a suitable pedestal. The roller is held against the slack side of the belt by counterweight (D). Some types of this drive have the roller assembled on two arms mounted on a shaft supported by one or two pedestals. The roller pulley is on a revolving shaft mounted on ball bearings. The shaft for the pedestal to which the arm is fastened is free to oscillate in a bearing in the head of the pedestal.

To go into detail on all of the advantages of this type of drive and into its theory and practice would consume much space. Below are given some of the principal advantages with a few brief explanatory remarks. One advantage, for example, is space saving. An excellent illustration of how this type of drive saves space is shown by the diagram on the next page.

Here original pulley centers of 19 ft. 3¼ in. were reduced to 4 ft. 6 in. This resulted in a considerable saving in space, belt and in the time formerly required for adjusting the old belt to keep it tight. The original installation was constantly giving trouble because of belt adjustment and belt wear. Except for an occasional oiling, the motor, drive and belt have not been touched since the installation was made in December, 1921.

Some of the other advantages may be discussed with brief explanations as follows: Pulleys may be located in almost any relation to each other as the line through the center of the pulleys can be at any angle to the floor line. Also, the belt can run in either direction and the unit is suitable for nearly all belt drives. The unit is entirely mechanical and automatic in its performance and needs no attention aside from occasional oiling, as it does not have complicated mechanism. This and the minimum bearing friction give a low cost of upkeep.

Because belts do not have to be so tight there is less wear, hence longer belt life. The shorter belts necessary give a lower belt cost. Sometimes narrower belts may be used to obtain the required output or increased capacity obtained from an installation. Belt clamps are not needed for tensioning or for splicing. This simplifies the splicing problem and saves much time. Also, as tension is maintained by the drive the belt does not need frequent attention. Arcs of contact of 225 deg. and more are frequently obtained and ordinarily difficult drives operated without applying belt dressings for the purpose of preventing slippage.

Endless belts are easily placed on or removed from the pulleys as the tension is applied after the belt is in place. This avoids the harmful practice of running a large belt onto a pulley by first forcing one of the edges to catch and then running the belt on either by hand or by power. Where overhung pulleys are used the belts can be made up endless by the belt manufacturer.

Great accuracy as to belt length is not so necessary with the special short-center drive as with the old style of drive. Also endless belts usually operate with less vibration. This type of short-center drive is elastic instead of rigid and so absorbs shocks and vibration which makes it an excellent drive for severe operating conditions. Also there is no flapping or waving of the belt, regardless of speed or load conditions. This also usually helps prevent vibration.

Still another advantage lies in the fact that as the operation does not require the maintaining of a high tension in the belt, the effectiveness of the drive is not affected by atmospheric conditions such as temperature and humidity nor by seasonal changes.

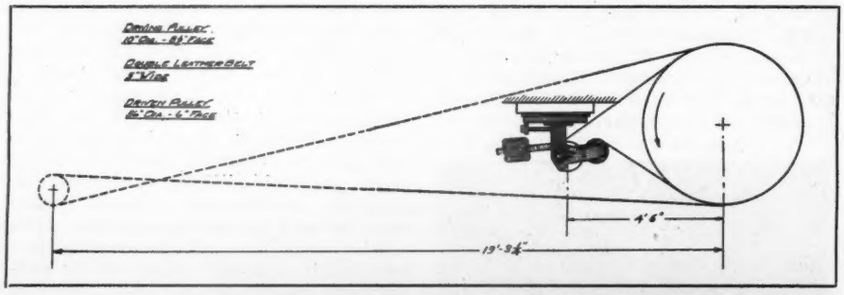
Sometimes important savings may be made by making additions and new construction unnecessary. In one instance short pulley centers gave enough additional space to save the cost of constructing an addition to a crusher building. Where direct-connected steam engines are replaced by motors and short-center drives, no more floor space, and frequently less, is required than formerly. Sometimes savings can be made in the cost of the equipment to which it is connected. For example, in some cases there is a reduced first cost of generators and motors because of the higher speeds which may be used. In some cases the entire cost of the special drive has been covered by the lowered price of the generator or motor which could not have been used with the ordinary open drive.

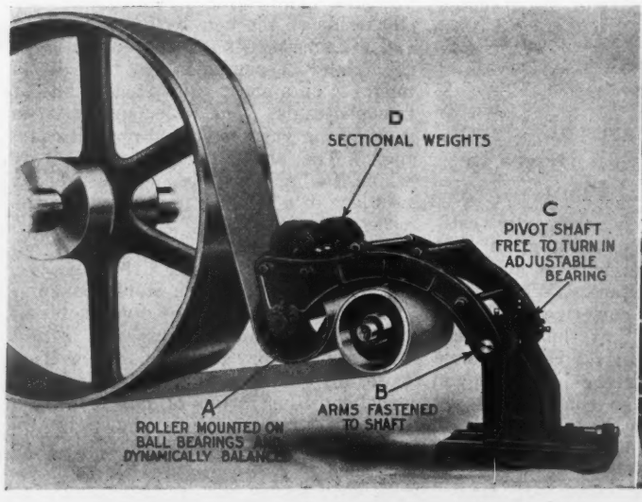
The first cost is low and the savings are further increased by reduced operating costs. Also, the speed reduction can generally be made in one step without extra countershafts or jackshafts. As this type of drive is simple it is easily and quickly installed by any man of average mechanical ability. Since there is nothing to get out of order the maintenance cost is low. Devices of this type are so simple that they can be operated by anyone as there is nothing to adjust. Bearing pressures, speeds and tensions may be determined so that the completed installation can be scientifically and practically correct. The larger contact of the belt on the pulley makes it unnecessary to lag the belt with leather or other materials. Iron, steel, wood, paper or any kind of pulley may be used. With the lower belt tension both belt and bearings will last longer. Also oil cannot leak from the ball bearing on the roller pulley shaft onto the belt and spoil it.

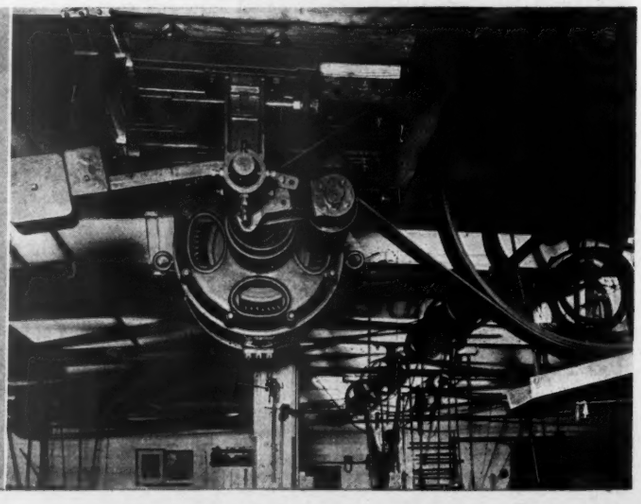
Operation at lower tension and the elimination of slip increase the efficiency of the drive over the whole range from light load to peak load. The minimum belt tension is constantly maintained. The initial tension on the slack side is a predetermined, fixed quantity. After its determination the tension on the slack side is practically held at that point. The old rule "make the lower side the pulling side" does not hold here. With drives of this type either the top or bottom may be the pulling side and with equally high efficiency. In addition, vertical drives are as readily handled as horizontal drives.

Construction details of a Pulmax belt drive and one lineshaft drive installation.

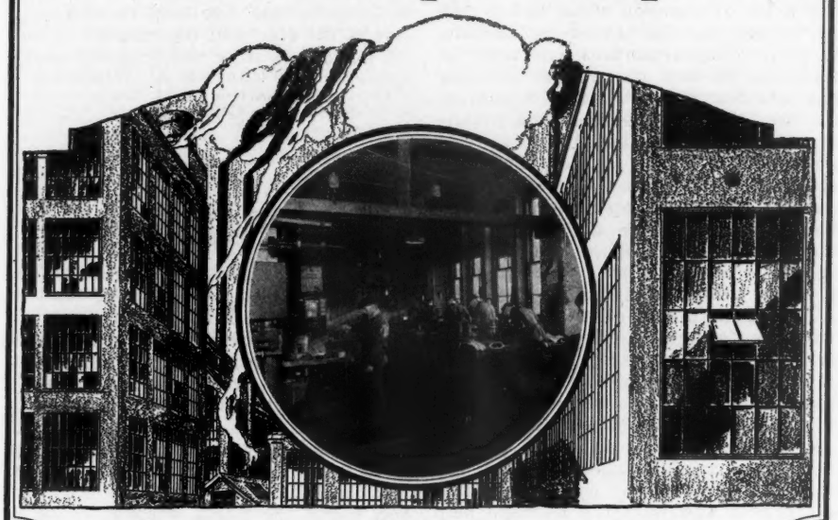
This drive, as shown in the illustration below, consists of the addition of a special pulley on a pivoted arm which increases the arc of contact of the belt upon the small pulley. The sketch shows how a lineshaft drive was shortened by means of a Pulmax drive. The lower illustration at the right shows the same installation as given in the sketch, which was made in Dec., 1921. The belt and drive have required no attention since, except oiling the pulley. Before this was installed the belt had to be tightened frequently.







In the Repair Shop



This section is devoted to repair work, large and small. Special attention is given to shop or bench tools and short cuts or improved methods. Contributions are always welcome.

Tests for All-Through Drying of Insulating Varnishes

A STATEMENT appearing in the article by the writer entitled, "When Analyzing Coil Troubles," and published in the July issue of INDUSTRIAL ENGINEER was challenged on page 398 of the August issue. The original statement in my article read as follows:

"Some materials have been sold on the claim that they will dry from the inside out and that, therefore, drying can be obtained all the way through. These materials have not been a success as it has been definitely proved that they will also form a skin over the outside surface, and when such a skin is formed the oxidation of the varnish base is stopped. Rather than select a material which must be sold by false claims it is much wiser to see what can be done towards remedying the difficulty by a proper method of treating the coils after the varnish has been applied."

Rather than enter into any discussion of the merits of the case I will describe two very simple experiments, by means of which anyone interested in the subject may demonstrate for himself whether any baking varnish dries throughout.

(1) Dip a sheet of bond paper 4 in. wide by 18 in. long and .0025 in. thick in the varnish in question and withdraw vertically at a slow, uniform rate of speed. Allow it to drain vertically for one-half hour; then bake in a well ventilated oven until dry. Upon removal from the oven an accumulation or bead of the varnish will be found to be formed on the lower edge. Tear this bead across and note the condition of the varnish, that is, whether any undried or only partially oxidized varnish can be squeezed out by the pressure of the fingers.

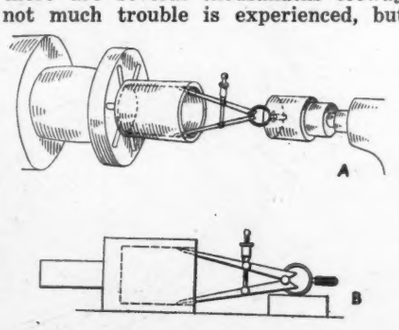
(2) Fill a small tin container about 3 in. in diameter with varnish to a depth of ¼ in. Place this in the drying oven and bake for 12 to 24 hrs. Examine the surface with the finger and note whether the same degree of toughness exists throughout or whether there is a skin over the surface. Breaking of the film will show very quickly the condition of the varnish underneath.

The writer believes that if these tests are carefully carried out the results will be the same as his own. In any case they should provide the reader with ample proof of the all-through drying qualities of any particular material.

H. L. HAZELTINE.
Engineer of Insulation,
The Sterling Varnish Co.,
Pittsburgh, Pa.

Accurate Method of Calipering Internal Work

THE difficulty of obtaining exact measurements with inside calipers are known to every mechanic. Where there are several thousandths leeway not much trouble is experienced, but when close limits must be maintained the situation often becomes tense, due to the difficulty of holding the calipers exactly centered throughout the entire length.



The calipers are held exactly in the center of the work by supporting them in the tail-stock chuck (A), or by placing the head on a block which, together with the work, rests on a surface plate (B).

An easy way to avoid these troubles and obtain more accurate measurements in less time than is ordinarily required is to support the handle of the calipers in the tail-stock chuck, as shown at (A) in the illustration, while taking measurements. The chuck is closed until it makes a loose sliding fit for the handle of the tool. By holding the caliper points in a vertical plane and sliding the handle back and forth in the chuck, it is possible to obtain accurate and dependable measurements almost instantly, as the support at the rear end eliminates about 80 per cent of the ordinary causes of error.

Where the work must be examined after it has been removed from the lathe, the same results may be obtained by placing both the work and a rectangular block for supporting the head of the calipers on a surface plate, as in (B). The spring clip of the calipers should in this case be placed on the block, as this gives a firm support, and the block must, of course, be about the right height to bring the handle of the calipers center with the work. In this case, either the calipers can be slid over the block, or the block and calipers together can be slid along toward and from the work.

Santa Ana, Calif. S. H.

Handling Repairs Profitably in the Plant Repair Shop

I HAVE read with much interest the "Topics Discussed by Steel Men" on page 464 of the October issue of INDUSTRIAL ENGINEER. Having been in maintenance work myself for several years I am prompted to make the following comments on the subjects discussed.

I notice in the article mentioned that several engineers have different opinions on the same subjects and one naturally wonders why there is this diversity of opinion. For instance, if "A" finds it profitable to rebuild commutators in his own shop but finds coil making unprofitable, and "B" finds the reverse, etc., why do the opinions differ? In all probability if "A" and "B" were doing the work themselves or were directly supervising it, they would both find it profitable to do both kinds of work.

I have been through the mechanical machine shop and electrical maintenance and have taken considerable pride in handling any job which came along whether I had ever seen it before or not, and doing it successfully, but I suppose that is why I am not doing it now.

Work which has come under my supervision, in the machinist line, ranges all the way from cylinder-lock repairing to shrinking tires on a locomotive, tool making, indexing and heat treating, turning large crankshafts and scraping in 30-in. valve seats, and from winding fan motor armatures up to those of 300-hp. size, both d. c. and a. c. The latter work included coil making,

rebuilding commutators, dipping, baking and practically everything connected with motor repairs.

As far as cost is concerned no one has ever taken the trouble to figure overhead expenses for the repair shop, but I keep an accurate record of time and material and if this cost is one-half or less than an outside price, it is usually done in our shop.

Our equipment is not expensive but electrical energy for power and light is generated and, due to our many uses for exhaust steam, is considered much cheaper than purchased power. But service is paramount to everything else. Much of our equipment cannot be down for more than one or two hours without special arrangement. When motors decide to burn out, they do not wait for special arrangements to be made; therefore, we are forced to make our own coils, rebuild our commutators, etc., and carry a large stock of spare armatures, bearings, pinions, and the like. While the expense of keeping this stock is considerable, I think it is more than offset by having plenty of time to do a thorough job of winding or repairing. My experience is that a job of winding which is hustled through at top speed, perhaps the winder working overtime all night, with a half-way job of painting using the quickest air-drying varnish obtainable, is a costly job.

Compare the same repair job with one when more time is available. The winder will use more care and thought, if he is at all conscientious and the job will be better insulated; coils and commutator all tested out properly with megger; undercut, if this is necessary, dipped in high-class baking varnish with plenty of time for baking and, if necessary, a double dip and baking. Whatever length of time the first armature requires, the second will run four times as long and will cost one-fifth more and be worth it.

There is one more thing regarding the making or buying of coils, bearings, etc. I have waited from six weeks to three months for various parts to come from one of the largest manufacturers of electrical equipment in this country, and that length of time does not go in our plant. This makes it necessary to have the equipment for handling these repair parts and we use it, get familiar with it and devise ways and means to do this work as good and as cheaply as possible. Much of this work figures for time and material less than one-third of the manufacturer's price, with the advantage of making the repairs in a few hours' time. Furthermore, electrical troubles with armatures have been reduced about 50 per cent within eighteen months at our plant, which, after all, is the justification of our procedure.

There is probably more vital detail work connected with armature winding and repair than with any other repair work in an industrial plant. For instance, a commutator may be tested with a lampbank and show clear. But put a megger on it and it will show a different story. The average reading may be 50 megohms with two bars showing 6,000 ohms. This would show clear with a lamp test at 250 volts, but something is certainly wrong and if it is not attended to, the result is a burned-out coil in a short time.

Men who handle repair work must use a lot of common sense and watch for every possible cause of trouble. In wire-wound armatures care must be taken to prevent wires from crossing one another without extra insulation between them. Be sure that all leads are run parallel, that there are no burrs on the inside of teeth and that slot insulation is not damaged when putting coils in. Keep coil shapers and hammers away from an armature as much as possible; shape the coil and spread it with the hands as much as you can before putting it in the slots. Also, seal both ends of the commutator with just a small amount of Bakelite cement before winding, to keep out dirt and oil. Be sure the bands are tight while being soldered and that the first and last turn are bent around the clip and caught with solder.

A most careful inspection when the work is completed will not always show up defects and with the average help available today if these details are not watched for while the winding is going on, more or less trouble is bound to follow.

A man to have charge of electrical equipment, repairs, and winding must have some natural mechanical and electrical ability coupled with theoretical and practical knowledge in order to compete successfully with large repair shops, both in cost and lasting equipment.

Where to find the above gem is always a question. The man who highly educates himself technically does not want to dirty his hands in the practical end, and the man who is the real practical stuff does not find the time to devote to a study of theoretical details of electrical and mechanical work. The few who are qualified to supervise these vital details are soon graduated to higher positions, leaving a place to be filled by one who may be less capable at the start but has chances of doing good work if he will properly apply himself.

CHESTER A. WILLIAMS.
Electrical Department,
Providence Gas Company,
Providence, R. I.

How to Make Adjustable Bench for Repair Work

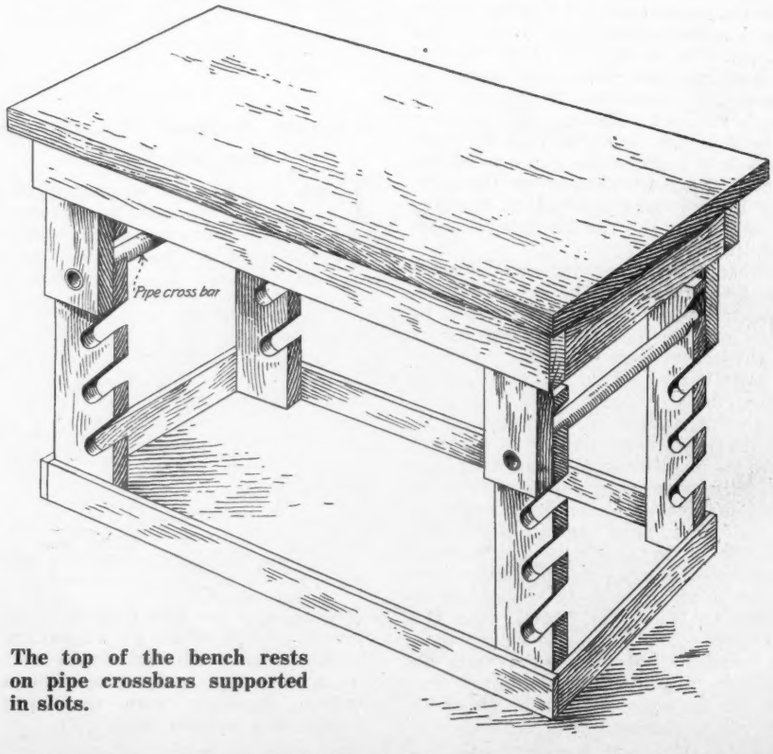
THE objectionable features of a bench which is too high or too low are overcome with the bench construction shown in the illustration. This is suitable for almost any kind of repair or construction work in wood or metal. Inasmuch as the height of the top can be adjusted, this bench can be used with equal convenience when working upon large parts which require that a low bench be used so that the workmen can reach the parts without using a footstool, as well as when doing small assembly or other work in which the top of the bench must be reasonably high in order to avoid the necessity of stooping to an uncomfortable position.

As shown in the illustration, the top is similar to that of the ordinary bench, while the legs are made up separately into a fixed stand.

Between the legs of the bench at each end, a pipe crossbar is placed as shown in the sketch. Diagonal slots are made in the legs at intervals of two or three inches. The bench top is supported by placing the cross bars in the slot.

Raising or lowering of the top is a simple matter of shifting the position of the crossbars in the slots.

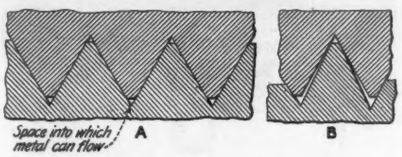
Washington, D. C. G. A. LUERS.



The top of the bench rests on pipe crossbars supported in slots.

How to Make Nuts Tight Fitting and Prevent Stripping

IT IS highly desirable to have tight fitting nuts on all machines, particularly punches and the like, where normal jarring tends to work them loose. As a rule nuts are put on to stay, but where parts have to be changed occasionally, as when changing bolsters or replacing worn rolls, the nuts that were originally close fitting soon become loose—a condition which is highly undesirable.



The threads are cut so as to leave a small space at the bottom into which metal can flow.

As a matter of fact, few threads produced without special thought in the matter will stand screwing and unscrewing of a nut more than two or three times without loosening up. The usual directions given to machinists are "make smooth threads and get a tight fit." And where directions are followed to the letter, stripped threads may be expected in a third of the applications.

There is a method of making threaded fits which will give a lasting fit under practically any number of removals, a fit which is tight and remains so, which is proof against stripping. In the illustration (A) shows the outline of this thread.

The secret of this "kink" lies in the flow of metals under pressure. It will be noted that there is a space at both top and bottom of the thread shape. Into this space the metal can flow when a tight nut is screwed on. If the nut and bolt are well oiled, any fit which can be screwed on with a wrench and not twist off the bolt can be made without stripping. It will be found that stripped threads (either with a die or a nut) result from clogging at the top or the bottom of the thread. The space should be there, in accordance with good practice, but it seldom actually is, due to lack of attention. The importance of this space in making permanent tight fits is not generally known.

A slight variation from this method, is that the male and female portions are cut at different angles, is shown exaggerated at (B). With such threads there is more room for flow; consequently a tighter fit is possible.

DONALD A. HAMPSON.
Plant Superintendent,
Morgans and Wilcox Mfg. Co.
Middletown, N. Y.

Truck Facilitates Handling of Heavy Armatures

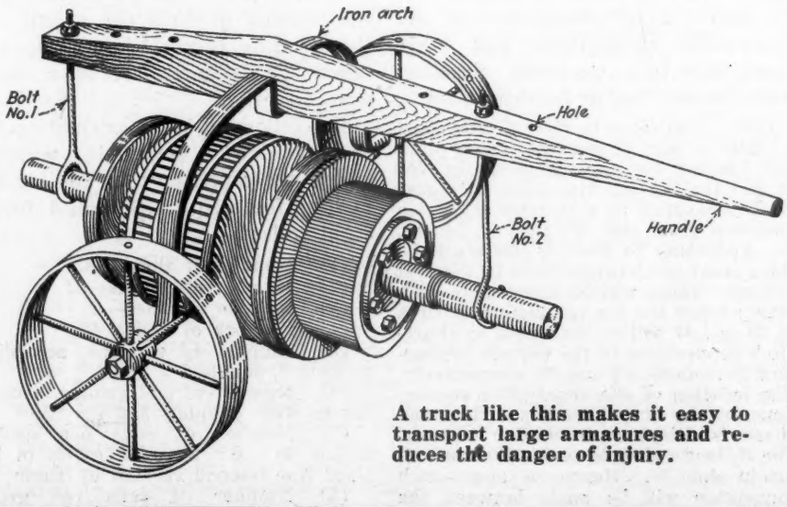
CARRYING heavy armatures to and from the repair shop and around the plant without injuring them is not an easy matter. Everyone who has handled armatures on a flat truck knows that they will sometimes roll off in spite of all precautions to prevent this mishap. Also, it does not take much to damage the commutator or coils.

The illustration shows a very handy truck which is used in the repair shop of a large plant, and has saved its cost many times over by preventing injury to armatures and making it easy to transport them around the plant.

Two iron wheels were salvaged from the junk pile and joined, as shown in the illustration, by a piece of heavy bar iron bent in the form of an arch. The ends were turned down to form an axle for the wheels. A groove or recess was forged in the center of the arch, into which a heavy hardwood handle was fitted. The handle is, of course, securely bolted to the arch. Two bolts in the handle support the armature. The first bolt, No. 1, is a long eyebolt, although it would probably be advisable, for convenience in handling, to make this bolt with a hook on the end. The other bolt should be made with a hook in the end and should preferably be suspended from an eyebolt, so that it will be free to swing. Both of the supporting bolts should be fairly long and threaded for a good portion of their length so that they can be raised or lowered as desired.

Several holes for these bolts should be bored in the handle so that different sizes of armatures can be accommodated.

Oakland, Calif. S. H. SAMUELS.



A truck like this makes it easy to transport large armatures and reduces the danger of injury.

Repairing Electric Elevators

(*Continued from page 518*)

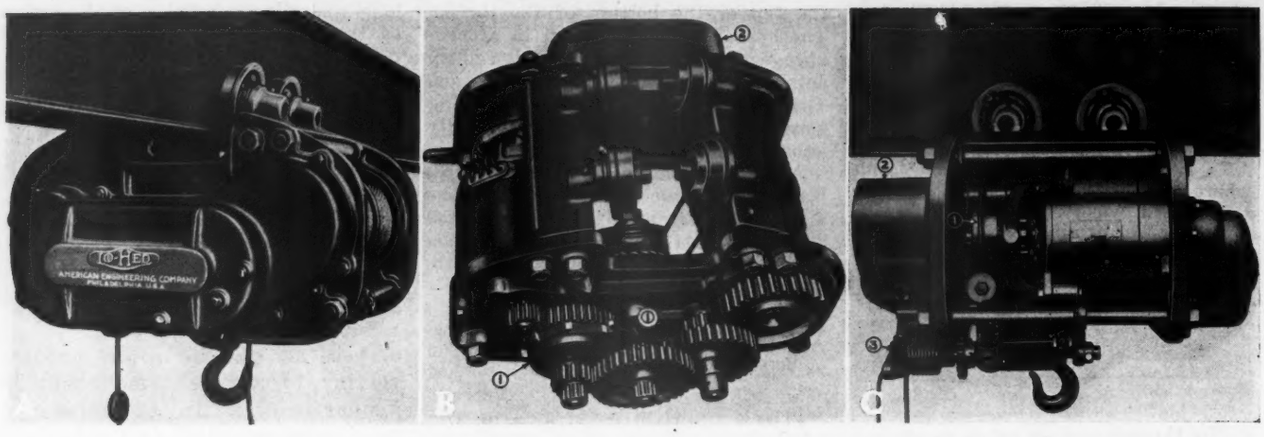
of used and rebuilt motors and the renting of motors came about in similar fashion. In the course of a few years we had accumulated a large number of motors which had come to us by direct purchase or through the replacement of existing installations with motors of greater capacity, and so on. As a matter of service to our customers we frequently had to install one of our own motors temporarily in the place of a damaged motor which was being repaired. In addition, we received many inquiries from individuals and concerns who, for one reason or another, wished to rent one or more motors for a time.

Starting in a rather small way, these branches of our business have grown to considerable proportions, and aside from the profits which they have made they have been of material assistance in carrying on the elevator repair and maintenance work which is the backbone of our business.

Motor rental is handled, in general, in the same way as has been outlined in the preceding pages. That is, when we receive an inquiry for the rental of a motor, the form shown in Fig. 2 *A* is made out and filed. This shows the price quoted. If the inquiry comes from a territory covered by one of our salesmen, he is given the white copy of the form and follows up the inquiry in person. Otherwise the rental price is confirmed in a letter. If our proposition is accepted the Rental Contract shown in Fig. 4 *F* is drawn up and signed by the customer and an official of our company.

In our experience we have found this form of contract very satisfactory as it covers every phase of such a transaction so completely that there is practically no opportunity for any misunderstanding or disagreement to arise regarding the rights and duties of each party to the contract.

That is an important consideration in any transaction.



This is a very compact arrangement of a small hoist having manual control with both lowering and holding brakes.

In illustration *A* is shown the hoist assembled complete. In *B* the enclosures have been removed so as to show the mechanism. At (1) is the mechanical lowering brake which is of the screw and disc type. The motor is shown at the left and the cable drum is opposite at the right. The controller is at (2) in both *B* and *C*. It is operated from a chain which is driven by the sprocket on the control arm (3) in illustration *C*. At (1) in *C* is shown the holding brake which is operated mechanically by the control arm (3). The limit stop also sets this brake in case of overtravel.

Operation of Small Hoists

(*Continued from page 530*)

open the electrical circuit to the actuating coil of the contactor, this being known as the pilot-circuit type limit switch. The main-circuit type of switch is the more positive, but must be made heavy enough to withstand the burning due to opening the motor circuit, whereas the pilot-circuit type may be relatively small, since it handles only the actuating-coil current.

The table on page 530 gives a summary of various accessories used on small electric hoists, indicating their relation to each other.

Laying Out Wave Windings

(*Continued from page 537*)

adjacent to and fall on the left side of the A_1 lead. In other words, they are in a counter-clockwise direction from A_1. These two short-pitch connections are in the first section of which A_1 is the starting lead. Likewise, there are two short-pitch connections in a similar position with reference to A_2. The latter are the short-pitch connections for the second section of which A_2 is the finishing lead. The same will be found to be true of the short-pitch connections in the second phase. This gives:

Rule 13—Adjacent to and in a counter-clockwise direction from the starting lead of the first section of a phase, will be found the slots from which start the short-pitch connections for that section, and the companion slots will be one short pitch away measured in a counter-clockwise direction for left-hand coils and measured in a clockwise direction for right-hand coils. Also, adjacent to and in a counter-clockwise direction from the finishing lead of the second section of a phase, will be found the slots from which start the short-pitch connections of the second section. The conductor adjacent to the starting or finishing lead will be a top conductor if the starting or finishing lead is a top conductor, and the other conductor to which the short pitch connects will be a bottom conductor if the first conductor is a top conductor, or *vice versa*. This applies to a left-hand winding. In the case of a right-hand winding, the short-pitch connections will start from slots in a clockwise direction from the starting or finishing lead.

(23) According to *Rule 13* and since A_1 falls in slot *1*, the first short pitch will connect the top conductor in slot *32* and the bottom conductor one short pitch measured in a counter-clockwise direction from slot *32*; that is, in slot *25*. According to *Rule 5*, there will be three short-pitch connections in the first section. These will be adjacent to each other; hence the top conductors in slots *32*, *31* and *30* will be connected by short-pitch connections to the bottom conductors in slots *25*, *24* and *23*, respectively. The location of the short-pitch connections for the second section of the same phase is found in a similar manner. The A_2 lead connects to the top conductor in slot *25*. Hence, a short-pitch connection will be made between the top conductor in slot *24* and the bottom conductor in a slot one short pitch measured in a counter-clockwise direction from slot *24*, that is, in slot *17*. As explained above, there are three short-pitch connections, hence, the top conductor in slots *24*, *23* and *22* will be connected by short-pitch connections to the bottom conductors in slots *17*, *16* and *15* respectively. Since the starting lead, B_1 of the first section of the second phase is in slot *21*, the short-pitch connections are in a similar manner found to be between the top conductors in slots *20*, *19* and *18* and the bottom conductors in slots *13*, *12* and *11*, respectively. Likewise, since B_2 falls in slot *13*, the short-pitch connections for the second section of the second phase are found to connect the top conductors in slots *12*, *11* and *10* with the bottom conductors in slots *5*, *4* and *3* respectively. This data checks that given in the third line, eleventh column of Table I.

The three-phase winding can be laid out in the same manner, except that to pick up the conductor to which the start of the C phase is connected, we must measure in a counter-clockwise direction from the A_1 lead a distance equal to twice the front pitch plus twice the number of coils per group. Also, the start of the B phase will be in a slot that is a number of slots measured in a counter-clockwise direction from the A_1 slot, equal to the front pitch plus the number of coils per group. If the winding is right-hand, the distance will be measured in a clockwise direction.

The following is the calculation for the layout of a series-star winding for a three-phase, four-pole motor having forty-eight slots and forty-eight coils:

(1) Number of slots—48.
(2) Number of phases—3.
(3) Number of poles—4.
(4) Number of coils—48.
(5) Number of sections, according to *Rule 3*, equals $2 \times 3 = 6$.
(6) Number of coil groups, according to *Rule 4* equals $3 \times 4 = 12$.
(7) Number of coils per section equals $48 \div 6 = 8$, as is given in the third line, second column of Table VI.
(8) Number of coils per group

equals $48 \div 12 = 4$, as is given in the third line, third column of Table VI.

(9) Number of short-pitch connections, according to *Rule 5*, will equal $[(48 \div 4) \div 3] - 1 = 3$.

(10) The total winding pitch equals $48 \div 2 = 24$.

(11) The back pitch is equal to $24 \div 2 = 12$, or a pitch of 1-and-13, as is given in the third line, fourth column of Table VI.

(12) The front pitch is equal to $24 - 12 = 12$, or a pitch of 1-and-13.

(13) The pick-up pitch is equal to $12 + 4 - 1 = 15$, or a pick-up pitch of 1-and-16.

(14) The short pitch is equal to $12 - 1 = 11$.

(15) This winding is to be wound left hand and the line leads are to connect to top conductors in the slots; therefore, the A_1 lead will connect to the top conductor in slot *1*, which is the value given in the third line, fifth column of Table VI.

(16) The B_1 lead will fall in a slot measured in a counter-clockwise direction from the A_1 slot, a distance equal to the front pitch plus the number of coils per group, or $12 + 4 = 16$. Therefore, the B_1 lead will fall in $1 + 16 =$ slot *17*, which is the value given in the third line, sixth column of Table VI.

(17) The C_1 lead will fall in a slot measured in a counter-clockwise direction from the A_1 slot, a distance equal to two front pitches plus twice the number of coils per group, or $(2 \times 12) + (2 \times 4) = 32$. Therefore, the C_1 lead will fall in $1 + 32 =$ slot *33*, which is the value given in the third line, seventh column of Table VI.

(18) The A_2 lead will connect to a top conductor in a slot that is a front pitch measured in a counter-clockwise direction from the A_1 lead. Therefore, the A_2 lead will fall in $49 - 12 =$ slot *37*, as is given in third line, eighth column of Table VI.

(19) Likewise, the B_2 lead will fall in $17 - 12 =$ slot *5*, as given in the third line, ninth column of Table VI.

(20) Likewise, the C_2 lead will fall in $33 - 12 =$ slot *21*, as given in the third line, tenth column of Table VI.

(21) As stated in item 19 in the preceding calculation and according to *Rule 7* the R_1 reversing jumper lead will fall a distance measured in a counter-clockwise direction from the A_1 lead equal to one pick-up pitch; that is, the R_1 lead will fall in $49 - 15 =$ slot *34*. Therefore, the R_1 lead will connect to the bottom conductor in slot *34*.

(22) According to *Rule 8*, the R_2 lead will fall one front pitch measured in a counter-clockwise direction from the first reversing jumper; that is, the R_2 lead will fall in $34 - 12 =$ slot *22*. It will connect to a bottom conductor in slot *22*.

(23) In a manner similar to item 21, R_3 is found to fall in $17 - 15 =$ slot *2*.

(24) In a manner similar to item 22, R_4 is found to fall in $50 - 12 =$ slot *38*.

(25) R_5 will fall in $33 - 15 =$ slot *18*.

(26) R_6 will fall in $18 - 12 =$ slot *6*

Items 21 to 26 are given in the third line, eleventh column of Table VI.

(27) According to *Rule 13* and since there are three short-pitch connections per section, the first group of short-pitch connections will connect the top conductors in slots *48*, *47* and *46* with the bottom conductors in slots that are a distance of one short pitch measured in a counter-clockwise direction from the above slots; that is, in slots, *37*, *36* and *35* respectively.

(28) In a similar manner the short-pitch connections for the second section of the A phase will be found to connect the top conductors in slots *36*, *35* and *34* with the bottom conductors in slots *25*, *24* and *23* respectively.

(29) Likewise, the short-pitch connections for the first section of the B phase will be found to lie adjacent to

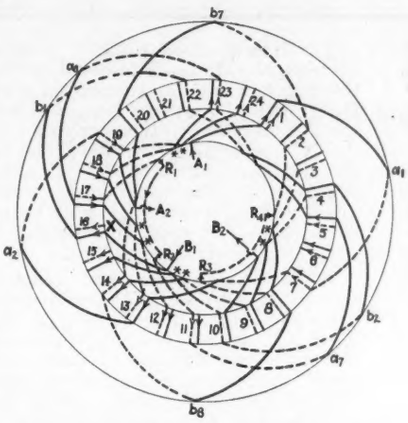


Fig. 1—Method of locating the short-pitch connections.

This winding is wound left-hand for a four-pole, two-phase machine. It will be noticed that the short-pitch connections (marked with asterisk) start from slots adjacent to and in a counter-clockwise direction from the slots to which the line leads connect. For example the short-pitch connections for the first section of the A phase start from slots *24* and *23*, which are adjacent to and in a counter-clockwise direction from slot *1*, to which the A_1 lead connects.

the B_1 lead; that is, the short-pitch connections will connect the top conductors in slots *16*, *15* and *14* with the bottom conductors in slots *5*, *4* and *3* respectively.

(30) In a similar manner, the short-pitch connections for the second section of the B phase will be found to lie adjacent to the B_2 lead; that is, the short-pitch connections will connect the top conductors in slots *4*, *3* and *2* with the bottom conductors in slots *41*, *40* and *39* respectively.

(31) The short-pitch connections for the first section of the C phase will lie adjacent to the C_1 lead; that is, the short-pitch connections will connect the top conductors in slots *32*, *31* and *30* with the bottom conductors in slots *21*, *20* and *19* respectively.

(32) The short-pitch connections for the second section of the C phase will fall adjacent to the C_2 lead; that is, the short-pitch connections will connect the top conductors in slots *20*, *19* and *18* with the bottom conductors in slots *9*, *8* and *7* respectively. The data given in items 27 to 32 inclusive is given in the twelfth column, third line of Table VI.

The rules and explanations that have been given in the preceding pages will enable the winder to lay out any wave winding either right- or left-hand wound, and having the leads connected to top or to bottom conductors. It will pay the winder to construct a few diagrams in the manner that has been shown until the different points peculiar to this type of winding are thoroughly mastered. The same procedure is followed in connecting a winding as is used in constructing the diagram and after the rules are once learned it is a simple matter to calculate the data or check a winding.

In the concluding article of this series will be given tables and data for use on wave windings for rotor and for stator windings having 120-deg. spacing between the line leads. Methods of laying out and determining the overlapping phase belts in windings where the number of slots is not a multiple of the number of poles will also be discussed.

Ways of Obtaining Variable Speeds

(*Continued from page 524*)

them in order to get the speed change. Their advantage lies in the fact that the change can be quickly made by merely shifting one of the pulleys across the face of the other. On the other hand, the friction surface wears rapidly and requires frequent renewal or maintenance. This is due to the fact that the parts of the faces of the two pulleys in contact with each other do not travel at the same rate of speed.

No effort will be made here to describe any of the various, special mechanical devices consisting of sliding arms or links which may be shifted and thus vary the speed, that have been brought out. Many of these have been impractical "freaks" that did not get beyond the model stage or the patent office. In some types, which would operate, the wear is too great or other practical features are lacking which prevent them having extended use.

In conclusion it may be well to point out that almost all machines have a one best speed for each kind or class of work. Also that in some cases this best speed will vary from day to day, due to climatic conditions. With provision for obtaining a variable speed the best and most effective operating speed can be obtained for each condition.

EDITOR'S NOTE: Acknowledgment is made to the following companies for assistance in furnishing information and photographs for this article: Lewellen Mfg. Co., Columbus, Ind.; The Moore & White Co., Philadelphia, Pa.; The Oilgear Co., Milwaukee, Wis.; Reeves Pulley Co., Columbus, Ind.

Trade Literature
You Should Know About

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of bulletin or catalog desired, as given in these columns.

Cooper-Hewitt Electric Company, 95 River Street, Hoboken, N. J.—A 32-page booklet entitled "Work-Light" gives in a slightly technical manner an interesting discussion of the relation between work and illumination. Among the subjects discussed are: Adapting light to a purpose; why Cooper-Hewitt is work light; work-light and its work; the economy of work-light; planning a work-light installation; the maintenance of work-light; the service behind work-light.

The Safety Equipment Service Company, 1104 Hamilton Avenue, Cleveland, Ohio.—A booklet describes the Electro safety punch press guard. This affords protection to workers by requiring each of the one or more operators to press two push buttons simultaneously in order to trip the press and so assures that all have their hands out of danger. The booklet shows numerous illustrations of installations and also gives an installation wiring diagram.

The Martindale Electric Company, 11709 Detroit Avenue, Cleveland, Ohio—Bulletin describes the Imperial Blow-er Clean which operates either as a portable suction cleaner or blower for removing dust and other accumulations from machinery, particularly electrical installations.

Buffalo Pulley and Caster Company, Inc., Buffalo, N. Y.—A folder describes Belt-Grip leather pulleys which are made of solid leather discs and so give a leather-to-leather contact.

Allan Manufacturing and Welding Company, Inc., Buffalo, N. Y.—A folder describes the Almanac electric welding and cutting equipment and accessories, such as electrodes and holders, shields and helmets.

The Industrial Electric Company, 5230 St. Clair Avenue, Cleveland, Ohio—A folder describes the Indian constant potential charging plant which is a motor-generator set with indicating and control apparatus, built to charge any sizes of batteries in one day. When being charged with this outfit, batteries are connected in multiple instead of in series.

Armature Coil Equipment Company, 2415 Forestdale Avenue, Cleveland, Ohio—A folder describes the insulated or bare strap copper bar bender which is made in two sizes. The smaller size takes stock ½ in. to ¾ in. width and the larger machine handles bars 1 in. thick to 1¼ in. wide, without damaging insulation.

Whiting Corporation, Harvey, Ill.—Type C electric solenoid brake, which is a quick-acting, powerful brake designed especially for crane service, is described in a special folder. This also includes the description of a foot brake.

G. M. Bartlett, 2533 College Avenue, Indianapolis, Ind.—A folder describes the Bartlett angular transmission for transmitting power between two shaft ends at a uniform angular velocity ratio of 1 to 1 with shaft angular displacement of 90 deg. or more. This can also be used with parallel offset shafts. Power is transmitted through a joint somewhat similar to a special universal coupling.

W. A. Jones Foundry and Machine Company, 4401-4451 West Roosevelt Road, Chicago, Ill.—Catalog 29 devotes 250 pages to a discussion, description and prices of Jones spur, bevel, mitre, worm and spiral gears with either cut or moulded teeth and spur and worm gear speed reducers. In addition there are several pages of general engineering data.

The North American Manufacturing Company, Cleveland, Ohio—A folder describes the North American gas-electric portable blow torch and some of its various applications. This consists of a small electric blower to furnish an air blast in the gas mixture and will develop temperatures from 500 deg. F. to 2,500 deg. F.

Pyott Foundry Company, 328 North Sangamon Street, Chicago, Ill.—Catalog 28 describes in 160 pages the line of cast-iron pulleys, sheaves, sprocket wheels, molded-tooth gears, power transmission machinery and special gray-iron and semi-steel castings.

Mutual Electric and Machine Company, Detroit, Mich.—A folder describes the Bull Dog "Luminized" safety switch which has a permanent, lustrous, aluminum finish on the switch box and is not only more visible in the dark through the reflection of light on its surface but also has a surface which is claimed to resist rust, acids and alkalies and to be easier to keep clean.

Morse Chain Company, Ithaca, N. Y.—Publication 24 entitled "Large Power Drives" illustrates a number of applications of Morse silent chains of 100 to 5,000 hp. rating.

Fairbanks-Morse and Company, Chicago, Ill.—Bulletin H-288 entitled, "Ball-Bearing Motors for the Textile Industry," not only gives the construction and operation, but the advantages obtained from ball-bearing motors, particularly in textile mills. This description includes the Type T motors for individual drives of looms and similar machines, Type H motors for two- and four-frame drive and Type EH enclosed and ventilating motors for opener and picker-room drives and similar installations.

Reed Air Filter Company, Inc., Louisville, Ky.—Bulletin 106 describes the Reed system of air filtration, which consists of drawing the air through a cell consisting of closely interlocked filtering media covered with a viscous, adhesive coating upon which dust and dirt are deposited. The cells may be removed and cleaned. Other bulletins discuss tests, specifications and data, and the use of Reed air filters for general ventilation, for ventilation of electrical equipment, for air compressors, internal combustion engines and pneumatic equipment and for drying operations and bacterial control.

American Chemical and Engineering Company, 546 West Washington Street, Chicago, Ill.—A folder describes "Full Speed" pulley covering which consists of a fabric saturated with the compound and applied to the face of the pulley. This becomes hard and firm, is water-, oil-, acid- and fire-proof, and increases the friction hold of the belt on the pulley.

The Keystone Lubricating Company, Philadelphia, Pa.—A booklet entitled, "Send Him Back to Them—Safe," discusses the advantages of the Keystone manifold safety system of grease lubrication from a safety, fire prevention and industrial operation standpoint.

The New Departure Manufacturing Company, Bristol, Conn.—A folder entitled, "What New Departure Ball Bearings Mean in Your Electric Motor," lists some of the advantages which it is claimed result from the use of ball bearings in electric motors.

Dodge Manufacturing Corporation, Mishawaka, Ind.—Folders describe the new Dodge-Timken roller hanger bearing and show cutaway as well as sectional views of it. Dimensions and prices are also given.

Baker R. & L. Company, Industrial Division, Cleveland, Ohio—Catalog 24 on "Industrial Tractors and Trucks" devotes fifty-two pages to illustrating, describing and giving the specifications of the different types of industrial trucks and tractors, together with a wide line of industrial applications.

Anaconda Copper Mining Company

(Continued from page 511)

also in radio sets, in telegraph, telephone and in cable, in the piano, the talking machine, the automobile and in water service as plumbing pipe. They serve in over 50,000 different shapes, each rust-free and practically everlasting.

In the United States there is now a per capita consumption of almost 15 lb. of copper compared with 3.1 lb. for Europe.

The constantly growing demand by the public for better qualities and longer life in metal articles, the rapidly growing tendency to use more electrical energy, and other developments in science and industry indicate a steady growth in the demand for copper, not only in the United States but throughout the world.